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THE PARIS EXPOSITION OF 1889.

ONE of the best elaborated plans for the projected Paris exposition of 1889 is that of Messrs. Eiffel and Sauvestre, to whom the committee on competitive designs has awarded one of the four prizes of $800. In this project the department of fine arts would be located in the Palace of Industry, which would communicate with the right bank of the Seine by a temporary and inexpensive foot-bridge at a height of 16 ft. above the roadways along the wharves of the two banks.

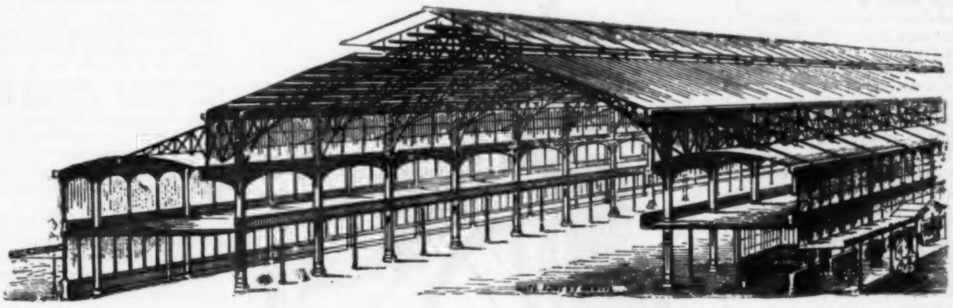
The agricultural exhibition would be located on the quincunxes of the D'Orsay wharf, and the maritime fluviatile ones on the banks of the Seine, between the Invalides and Jena bridges.

The different parts of the exposition divided by Avenue Latour-Mauboing and the approaches to Alma bridge would communicate with each other through passages running under the roadway, and to which access would be afforded by gentle slopes. These parts of the exposition, again, would be connected with the Champ de Mars by a large foot-bridge thrown over the open cutting toward Jena bridge, and over the road that runs along City of Paris Square. An interior tramway, utilizing the roads already existing between the Invalides and Alma bridges, would carry visitors to the interior of the exposition, from the Esplanade to the Champ de Mars.

The proposed arrangement of the buildings in the Champ de Mars is worthy of remark. The proposed buildings, which would have a vast space between them disposable for gardens, are remarkably elaborated, and, in general arrangement, recall the Palace of Industry, without the well-known defects of the latter. These defects, which relate to the lighting, would be remedied in the project under consideration by lighting the grand nave by means of vertical plates of glass and a skylight running along the peak of the roof, while the sides of the building would be entirely of glass.

Each of the large galleries extending along the Champ de Mars would consist of a central nave 105 feet in height by 163 in width, chiefly designed for machinery, and of two lateral parts 60 feet in width, with one story 67¼ ft. in width, inclusive of a gallery projecting 7¼ ft. A covered passage would run along the buildings externally.

On the ground floor, on the side toward the garden, the external half-width would be occupied by bars, cafes, restaurants, stores, etc. As for the story above, that would be divided into two parts by a partition that would permit of establishing on the outer side a series of well-lighted rooms which the noise from the machinery gallery would not reach. On the inner side there would be a vast promenade bordered by private exhibits. Walking would be rendered agreeable and attractive here through the projecting balcony, from which the public would enjoy a general view of the central gallery.



EIFFEL'S SYSTEM OF EQUILIBRATED TRUSSES.

The two buildings would be 320 ft. in total length, and would be connected at the end toward the Military School either by an analogous semicircular gallery or by a rectangular structure, to contain lecture halls, a large reception room, an exhibition of electricity, etc. The trusses that it is proposed to use in the large galleries are of a new and very ingenious style. Mr. Eiffel calls them "equilibrated trusses," because the object of them is to annul the thrusts produced upon the pillars of the grand nave. For this purpose, the trusses of the central part (see figure) are simply prolonged outwardly, and the roofing of the lateral galleries, being suspended from the lower part of these prolongations, counterbalances around the pillar the loads due to the roofing of the grand nave. This arrangement is remarkably advantageous as regards saving in metal, and will probably be definitely adopted.

Between the two main buildings it is proposed to erect the 984 foot tower, which we have already figured and described, and which is again shown in the accompanying engraving, which we borrow, along with these details, from *Le Genie Civil.*

MINING COAL BY HYDRAULIC MEANS.*

THE apparatus here described was applied for getting coal at the Backmuir Colliery of the Clyde Coal Company, Hamilton, fully three years ago. This apparatus is called the hydraulic test; but before laying our experiments before you, permit me to refresh your memories regarding the discussion which took place at the general meeting, 11th January, 1883. The discussion referred to was on Mr. Gilchrist's paper on "Blasting by Lime" at Earnock Colliery. During the discussion, the ex-president, Mr. Moore, said he "had always an idea if they introduced water, say at 2,000 lb. on the square inch, into the hole, and made it tight by means of India-rubber, they would by that pressure bring down the coal just as effectively as by lime, or powder, or any other means. Suppose two pistons, the diameter of the hole, were connected by a pipe 2 ft. long with a hole in it; by introducing this into a 3 in. hole, and pumping water in between the two pistons, the requisite amount of pressure could be got, while the one piston would balance the other, and there would be no tendency to be blown out, however much pressure was applied."

After this discussion, Mr. Hamilton, secretary of the Clyde Coal Company, and I had a conversation relative to the bringing down of the coal in the stooping at Backmuir Colliery, which resulted in this trial being made. At that time, Mr. D. Johnston, hydraulic engineer, Glasgow, was consulted, and arrangements were made to apply the hydraulic pressure as described by Mr. Moore to the forcing down of the coal. The place

* Transactions of the Mining Institution of Scotland, by R. Beith.


DESIGN FOR THE PARIS EXHIBITION BUILDINGS OF 1889, WITH TOWER 1,000 FEET IN HEIGHT.

selected for the trial was a part of the workings where stooping operations had been going on for some years, and where a lift 15 ft. wide was being taken from the side of a stoop. The place was holed 4½ ft. in for 15 ft. along the side of the stoop, after which three holes were drilled. The first hole was put in 6 ft. from the corner of the stoop; it was 3 in. in diameter and 4 ft. deep; the second hole was 4 ft. from the first, and the third was also 4 ft from the second—the holes being placed much in the same position as when powder was used, that is to say, about the same distance from the roof.

The arrangements being completed, the experiments were proceeded with in the presence of Messrs. Hamilton, Fairweather, Johnston, and myself. The results of the first day's experiments were comparatively *nil*. The pump used had a ram 1½ in. in diameter, with a lever several feet in length, which was not sufficient to give the pressure required. Consequently, the experiments had to be abandoned for that day, and another pump got.

The pump secured for the second day's experiments was of the following dimensions, viz., the ram was ⅝ in. diameter, with a leverage on the handle of four to one. With this pump a good pressure was got; and on the thrusts of the pump, we can safely say, there was a pressure of 1,000 lb. on the square inch. When the pressure was at its best, the coal cracked and made a great noise as if coming down; and from the noise it made we thought that the experiments were going to be successful, but unfortunately the water commenced to ooze through invisible seams, coming out of the coal like a dew, and forming little streamlets while the men kept pumping. At the same time when the coal cracked and sounded as if it were giving away, the pressure was at its best, and it must only have been the expanding of very small passages, as in no place did the escaping water come away with a spout, but formed like a dew over various parts of the coal, and which combining formed a tiny streamlet. When we saw this, we did not prosecute the experiments any further.

TORPEDO BOAT FOR THE JAPANESE GOVERNMENT.

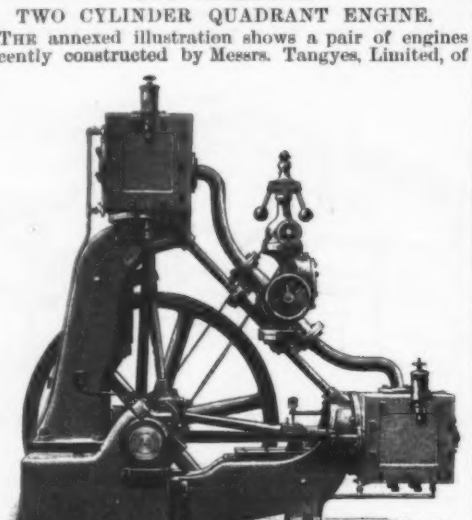
WE give an illustration of a torpedo boat lately completed by Messrs. Yarrow & Co., of Poplar, for the Japanese government, which is of more than usual interest, as she is a distinct departure from the now stereotyped form of torpedo boat. Not only is she the largest that has hitherto been built, but she embodied several new features. The principal novelty is that the vulnerable parts of the vessel, including the machinery, are all protected by one-inch steel armor, which may be considered as an almost perfect defense against machine-gun fire, having in view the distance at which a torpedo boat attacks and the acute angle of fire at which it would be hit.

The dimensions are 166 ft. long by 19 ft. beam, and she will be propelled by twin screws driven by engines indicating 1,400 horse power, from which a speed of nineteen to twenty knots an hour may be reasonably expected. The vessel has already been shipped in pieces to Japan, where she will be put together; and if the trials come up to the expectations formed, there is no doubt that this type of torpedo boat will find much favor with many governments. For not only is good protection obtained, but the vessel, from her large size, offers great and very comfortable accommodation for the officers and crew, and is undoubtedly deserving of being considered as thoroughly seagoing. How far the advantages gained by the one-inch steel armor will counterbalance the disadvantages of reduced speed, and increased cost in consequence, is for naval authorities, rather than for engineers and shipbuilders, to determine.

The armament will consist of two torpedo tubes placed forward for direct ahead firing, the torpedoes being ejected by gunpowder. There will also be amidships and aft, on the deck, turntables, upon each of which will be mounted two torpedo guns, placed at an acute angle with one another, and arranged for firing over the side. These guns, by being nearly but not quite parallel with each other, if fired simultaneously, will clearly very materially increase the probability of the vessel aimed at being hit. It is a remarkable fact that the Japanese were the first to introduce seagoing torpedo boats into their navy, Messrs. Yarrow & Co. having, some eight years ago, constructed a number of such craft for the Japanese government, under the superintendence of Sir E. J. Reed. Again they have taken the initiative, in conjunction with Messrs. Yarrow & Co., in adopting a vessel of such an entirely new type and possessing such evident advantages over their predecessors.—*The Engineer.*

TWO CYLINDER QUADRANT ENGINE.

THE annexed illustration shows a pair of engines recently constructed by Messrs. Tangyes, Limited, of



IMPROVED QUADRANT ENGINE.

Birmingham, for working the dynamos on board the City of Dublin Steam Packet Company's new vessel Ireland. The very limited space available necessitated the construction of engines of a special design, these, as a matter of fact, measuring over all 7 ft. long by 6 ft. 5 in. high by 3 ft. 9 in. wide. The steam cylinders are 10 in. in diameter by 10 in. stroke, both connecting rods working on the same crank. To prevent vibration, the vertical and horizontal engine standards are stayed by a wrought-iron rod, which also serves to carry the high-speed governor. The connecting steam pipes are of copper. All the working parts are of steel, and special lubricators are provided for oiling them while in motion. The power is taken off by belting from flywheel on one side of the engine, so keeping the other side free for the attendant.—*Engineering.*

CORK.

ON NEW APPLICATIONS OF THE MECHANICAL PROPERTIES OF CORK TO THE ARTS.*

By WILLIAM ANDERSON.

IT would seem difficult to discover any new properties in a substance so familiar as cork, and yet it possesses qualities which distinguish it from all other solid or liquid bodies, namely, its power of altering its volume in a very marked degree in consequence of change of pressure. All liquids and solids are capable of cubical compression or extension, but to a very small extent; thus water is reduced in volume by only $\frac{1}{20000}$ part by the pressure of one atmosphere. Liquid carbonic acid yields to pressure much more than any other fluid, but still the rate is very small. Solid substances, with the exception of cork, offer equally obstinate resistance to change of bulk; even India rubber, which most people would suppose capable of very considerable change of volume, we shall find is really very rigid.

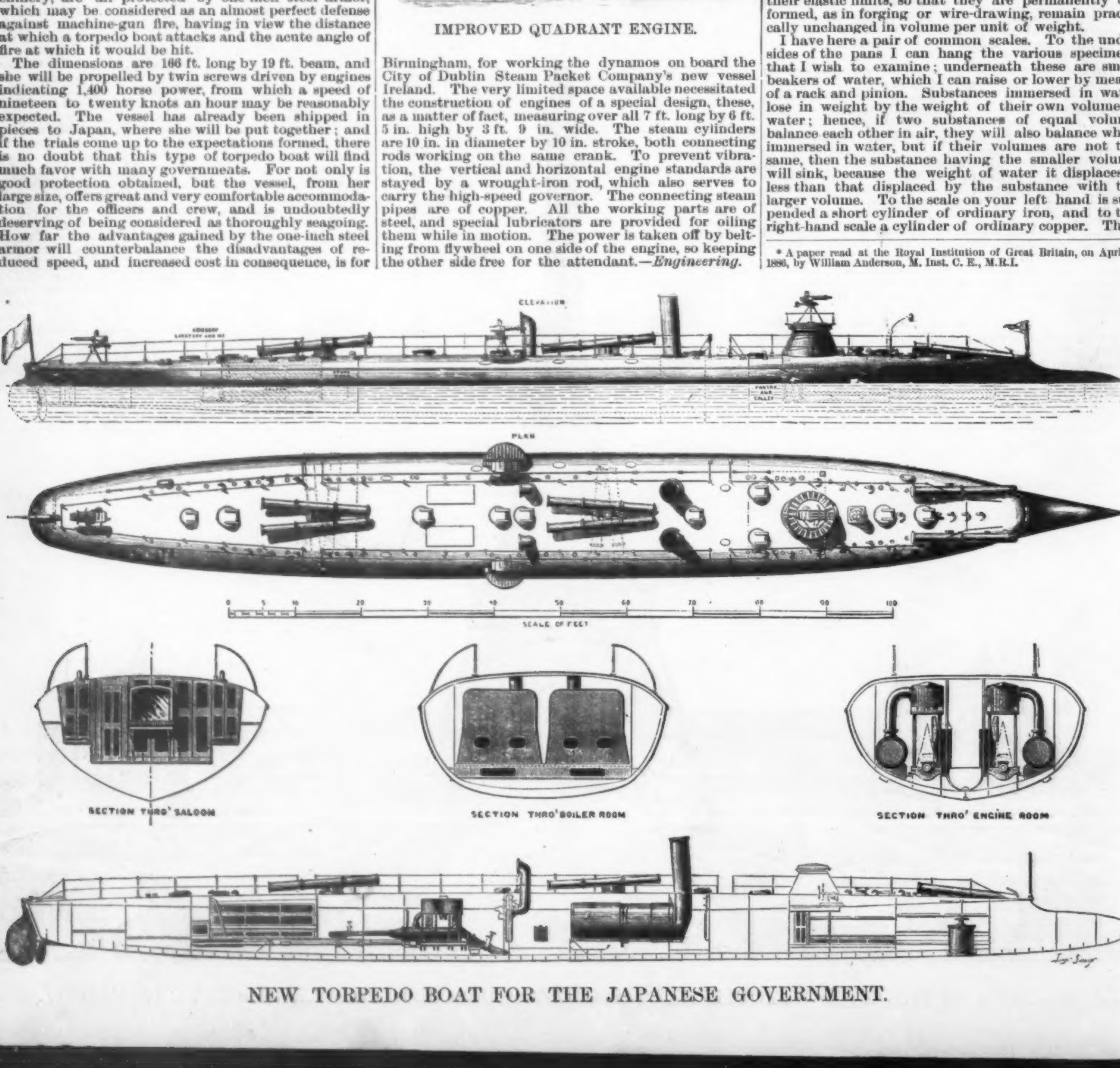
I have here an apparatus for applying pressure by means of a lever. I place a piece of solid India rubber under the plate, and you see that I can compress it considerably by a very light pressure of my finger. I slip this same piece of India rubber into a brass tube, which it fits closely, and now you see that I am unable to compress it by any force which I can bring to bear. I even hammer the lever with a mallet, and the blow fails as it would on a stone. The reason of this phenomenon is that, in the first place, with the India rubber free, it spread out laterally while being compressed longitudinally, and, consequently, the volume was hardly altered at all; in the second case, the strong brass tube prevented all lateral extension, and because India rubber is incapable of appreciable cubical compression, its length only could not be sensibly altered by pressure.

Extension, in like manner, does not alter the volume of India rubber. In this glass tube is a piece of solid round rubber which nearly fills the bore. The lower end of the rubber is fixed in the bottom of the tube, and the upper end is connected by a fine cord to a small windlass, by turning which I can stretch the rubber. I fill the tube to the brim with water, and throw an image of it on to the screen. If stretching the rubber either increases or diminishes its volume, the water in the tube will either overflow or shrink in it. I now stretch the rubber to about three inches, or one-third of its original length, but you cannot see any appreciable movement in the water level, hence the volume of the rubber has not changed.

Metals, when subjected to pressures which exceed their elastic limits, so that they are permanently deformed, as in forging or wire-drawing, remain practically unchanged in volume per unit of weight.

I have here a pair of common scales. To the under sides of the pans I can hang the various specimens that I wish to examine; underneath these are small beakers of water, which I can raise or lower by means of a rack and pinion. Substances immersed in water lose in weight by the weight of their own volume of water; hence, if two substances of equal volume balance each other in air, they will also balance when immersed in water, but if their volumes are not the same, then the substance having the smaller volume will sink, because the weight of water it displaces is less than that displaced by the substance with the larger volume. To the scale on your left hand is suspended a short cylinder of ordinary iron, and to the right-hand scale a cylinder of ordinary copper. They

* A paper read at the Royal Institution of Great Britain, on April 9, 1886, by William Anderson, M. Inst. C. E., M.R.I.



NEW TORPEDO BOAT FOR THE JAPANESE GOVERNMENT.

balance exactly. I now raise the beakers and immerse the two cylinders in water; you see the copper cylinder sinks at once, and I know by that that copper has a smaller volume per pound than iron, or, as we should commonly say, is heavier. I now detach the copper cylinder, and in its place hang on this iron one, which is made of the same bar as its fellow cylinder, but forced, while red hot, into a mould by a pressure of sixty tons per square inch, and allowed to cool under that pressure. The two cylinders balance, as you see. Has the volume of the iron in the compressed cylinder been altered by the rough treatment it has received? I raise the beakers, immerse the cylinders, the balance is not destroyed; hence, we conclude that, although the form has been changed, the volume has remained the same. I substitute for the hot compressed cylinder one pressed into a mould while cold, and held there for some time, with a load of sixty tons per square inch; the balance is not destroyed by immersion, hence the volume has not been altered. I can repeat the experiments with these copper cylinders, and the result will be found the same. Extension, also, is incapable of appreciably altering the density of metals. I attach to the scales two specimens of iron taken from a bar which had been torn asunder by a steady pull. One specimen is cut from the portion where it had not been strained, and the other from the very point where it had been gradually drawn out and fractured. The specimens balance, I immerse them, and you see the balance is not destroyed; hence, the volume of the iron has not been changed appreciably by extension.

But cork behaves in a very different manner. I place this cylinder of cork into just such a brass tube as served to restrain the India rubber, and apply pressure to it in the same way; you see I can readily compress the cork, and when I release it, it expands back to its original volume; the action is a little sluggish on account of the friction of the cork against the sides of the tube. In this case, therefore, a very great change in the volume of the material has been easily effected.

But, although solids evidently do not change sensibly in bulk, after having been released from pressures high enough to distort them permanently, yet, while actually under pressure, the volumes may have been considerably altered. As far as I am aware, this point has not been determined experimentally for metals, but it is very easy to show that India rubber does not change.

I have here some of this substance, which is so very slightly lighter than water that, as you see, it only just floats in cold water, but sinks in hot. If I could put it under considerable pressure while afloat in cold water, then, if its volume became sensibly less, it ought to sink. In the same way, if I load a piece of cork and a piece of wood so that they barely float, if their volumes alter, they ought to sink.

In this strong upright glass tube I have, at the top, a piece of India rubber, immediately below it a piece of wood, and below that a cork; the wood and the cork are loaded with metal sinkers, to reduce their buoyancy. The tube is full of water, and is connected to a force-pump, by means of which I can impose a pressure of over one thousand pounds per square inch. The image of the tube is now thrown on the screen, and the pressure is being applied. You see at once the cork is beginning to shrink in all directions, and now its volume is so reduced that it is incapable of floating, and sinks down to the bottom of the tube. The India rubber is absolutely unaffected, the wood does contract a little, but not sufficiently to be visible to you or to cause it to sink. I open a stop-cock, and relieve the pressure; you see that the cork instantly expands, its buoyancy is restored, and it floats again. By alternately applying and taking off the pressure, I can produce the familiar effect so well known in the toy called "the bottle imps." It is this singular property which gives to cork its value as a means of closing the mouths of bottles. Its elasticity has not only a very considerable range, but it is very persistent. Thus, in the better kind of corks used in bottling champagne and other effervescing wines, you are all familiar with the extent to which the corks expand the instant they escape from the bottles. I have measured this expansion, and find it to amount to an increase of volume of seventy-five per cent., even after the corks have been kept in a state of compression in the bottles for ten years. If the cork be steeped in hot water, the volume continues to increase till it attains nearly three times that which it occupied in the neck of the bottle.

When cork is subjected to pressure, either in one direction, as in this lever press, or from every direction, as when immersed in water under pressure, a certain amount of permanent deformation, or "permanent set," takes place very quickly. This property is common to all solid elastic substances when strained beyond their elastic limits, but with cork the limits are comparatively low. You have, no doubt, noticed in chemists' and other shops that, when a cork is too large to fit a bottle, the shopkeeper gives the cork a few sharp bites, or, if he be more refined, he uses a pair of specially contrived pincers; in either case he squeezes the cork beyond its elastic limits, and so makes it permanently smaller. Besides the permanent set, there is a certain amount of what I venture to call sluggish elasticity, that is, cork, on being released from pressure, springs back a certain amount at once, but the complete recovery takes an appreciable time.

While I have been speaking, a piece of fresh cork, loaded so as barely to float, has been inserted into the vertical glass pressure tube. I apply a slight pressure, you see the cork sinks. I release the pressure, and it rises briskly enough. I now apply a much higher pressure for a moment or two, I release it, and the cork will either not rise at all, or will do so very slowly; its volume has been permanently altered; it has taken a permanent set.

In considering the properties of most substances, our search for the cause of these properties is baffled by our imperfect powers and the feeble instruments we possess for investigating molecular structure. With cork, happily, this is not the case; an examination of its structure is easy, and perfectly explains the cause of its peculiar and valuable properties.

All plants are built up of minute cells of various forms and dimensions. Their walls or sides are composed chiefly of a substance called cellulose, frequently associated with lignine, or woody matter, and with cork, which last is a nitrogenous substance found in many portions of plants, but is especially developed in the outer bark of exogenous trees, that is, trees belonging to an order, by far the most common in these latitudes, the stems of which grow by the addition of layers of fresh cellulose tissue outside the woody part and inside the bark. Between the bark and the wood is interposed a thin fibrous layer, which, in some trees, such as the lime, is very much developed, and supplies the bass matting with which all are familiar. The corky part of the bark, which is outside, is composed of closed cells exclusively, so built together that no connection of a tubular nature runs up and down the tree, although horizontal passages radiating toward the woody part of the tree are numerous. In the woody part of the tree, on the contrary, and in the inner bark, vertical passages or tubes exist, while a connection is kept up with the pith of the tree by means of medullary rays. In one species of tree, known as the cork oak, the corky part of the bark is very strongly developed. I project on the screen the magnified image of a horizontal section of the bark of the cork oak; you see nine or ten bands running parallel to each other; these are the layers of cellulose matter that have been deposited in successive years. I turn the specimen, and you now see the vertical section, with the radiating passages clearly marked.

The difference between the arrangement of the cells or tissue forming the woody part of the tree and the bark is easily shown. I have here three metal sockets, supported over a shallow wooden tray. Into them are fitted, first, a cork cut out of the bark in a vertical direction; next, a cork cut in a radial direction; and, lastly, a piece of common yellow pine. By means of my force-pump, I apply a couple of atmospheres of hydraulic pressure. I project an image of the apparatus on the screen, and you see the water has made its way through the wood and through the cork cut in the radial direction, while the cork cut in the vertical direction is impervious.

The cork tree, a species of evergreen oak, is indigenous in Portugal and along both shores of the Mediterranean. The diagram on the wall has been painted from a sketch obligingly sent to me by Mr. C. A. Friend, the resident engineer of the Seville Waterworks, to whom I am also indebted for this branch of a cork tree, these acorns, this ax used in getting the cork, and for a description of the habits of the tree, its cultivation, and the mode of gathering the harvest.

The cork oak attains a height of thirty to forty feet; it is not cultivated in any way, but grows like trees in a park. The first crop is not gathered till the tree is thirty years old, the next, nine or ten years later; both these crops yield inferior cork, but at the third crop, gathered when the tree is fifty years old, the bark has attained full maturity, and after that will yield the highest quality of cork every nine or ten years. In the autumn of the year, when the bark is in a fit state, that is, for small trees, from three-quarters of an inch to one inch thick, and for larger ones up to one inch and a half, a horizontal cut is made, by means of a light ax, like the one I hold in my hand, through the bark a few inches above the ground; succeeding cuts are made at distances of about a yard, up to the branches, and even along some of the large ones, then two or more vertical cuts, according to the size of the tree, and the bark is ripped off by inserting the wedge-shaped end of the ax-handle. In making the cuts, great care is taken to avoid wounding the inner bark, upon the integrity of which the health of the tree depends; but where this precaution is taken, the gathering of the cork does not in any way injure the tree.

After stripping, the cork is immersed for about an hour in hot water, it is dressed with a kind of spokeshave, then laid out flat and weighted in order to take out the curvature; it is then stacked in the open air, without protection of any kind, for cork does not appear to be susceptible of receiving injury from the weather.

The minute structure of the bark is very remarkable. First, I project on the screen a microscopic section of the wood of the cork tree. It is taken in a horizontal plane, and I ask you to notice the diversity of the structure, and especially the presence of large tubes or pipes. I next exhibit a section taken in the same plane of the corky portion of the bark. You see the whole substance is made up of minute many-sided cells about $\frac{1}{750}$ of an inch in diameter, and about twice as long, the long way being disposed radially to the trunk. The walls of the cells are extremely thin, and yet they are wonderfully impervious to liquids. Looked at by reflected light, if the specimen be turned, bands of silvery light alternate with bands of comparative darkness, showing that the cells are built on end to end in regular order. The vertical section next exhibited shows a cross section of the cells looking like a minute honeycomb. In some specimens large numbers of crystals are found. These could not be distinguished from the detached elementary spindle-shaped cells, of which woody fiber is made up, were it not for the powerful means of analysis we have in polarized light. I need hardly explain to an audience in this Institution that light passed through a Nicol prism becomes polarized, that is to say, the vibrations of the luminiferous ether are all reduced to vibrations in one plane, and, consequently, if a second prism be interposed and placed at right angles to the first, the light will be unable to get through; but if we introduce between the crossed Nicols a substance capable of turning the plane of vibration again, then a certain portion of the light will pass. I have now projected on the screen the feeble light emerging from the crossed Nicols. I introduce the microscopic preparation of cork cells between them, and you see the crystals glowing with many-colored lights on a dark ground.

Minute though these crystals are, they are very numerous and hard, and it is partly to them that is due the extraordinary rapidity with which cork blunts the cutting instruments used in shaping it. Cork cutters always have beside them a sharpening-stone, on which they are obliged to restore the edges of their knives after a very few cuts.

The cells of the cork are filled with gaseous matter, which is very easily extracted, and which has been analyzed for me by Mr. G. H. Ogston, and proved to be common air. I have here a glass tube in which are some pieces of cork which have been cut into slices, so as to facilitate the escape of the air. I connect the tube with an exhausted receiver, and project the image on the screen. You see rising from the cork bubbles of air as numerous, but much more minute than the bubbles which rise from sparkling wines; much more minute, because the bubbles you see are expanded to seven or eight times their volume at atmospheric pressure, on account of the vacuum existing in the tube. The air will continue to come off for an hour or more, and from measurements made by Mr. Ogston, I find that the air occluded in the cork amounts to about 53 per cent. of its volume. The facility with which the air escapes compared with the impermeability of cork to liquids is very remarkable.

I throw on the screen the image of a section cut from a cork which was kept under a vacuum of about 26 inches for 5 days and nights; aniline dye was then injected, and yet you see that the color has not more than permeated the outermost fringe of cells—those, in fact, which had been broken open by the operation of cutting the cork. By keeping cork for a very long time in an almost perfect vacuum, and then injecting dye, a slight darkening of the general color of a section of the cork may be noticed, but it is very slight indeed. How, then, does the air escape so readily when the cork is placed *in vacuo*?

The answer is, that gases possess the property of diffusion, that is, of passing through porous media of inconceivable fineness. When two gases, such as hydrogen and air, are separated by a porous medium, they immediately begin to pass into each other, and the lighter gas passes through more quickly than the heavier.

I have here a glass tube, the upper end of which is closed by a thin slice of cork; the lower end dips into a basin of water. Some hours ago the tube was filled with hydrogen, which you know is about 14½ times lighter than air; consequently, according to the law of diffusion, it will get out of the tube through the cork quicker than the air can get in by the same means, and the result must be that a partial vacuum will be formed in the tube, and a column of water will be drawn up. You see that such has been the case, and we have thus proved that the cells of cork are eminently pervious to gases. The pores in the cell-walls appear, however, to be too minute to permit the passage of liquids.

I closed the end of a glass tube 11 mm. diameter with a disk of cork 1·75 mm. thick, cut at right angles to the axis of the tree. I placed a solution of blue litmus inside the tube, and suspended it in a weak solution of sulphuric acid. Had diffusion taken place, both liquids would have assumed a red color, but after sixteen hours no change whatever could be detected. A like inertness was exhibited when the tube was filled with a solution of copper sulphate and suspended in a weak solution of ammonia; a deep blue color would have appeared had any intermixture taken place, and the same tube is before you, immersed in ammonia and filled with red litmus solution. It has been in this condition since February 28, but no diffusion has taken place. A disk of wood 6 mm. thick, under the same circumstances, showed after a couple hours, by the liquids turning blue, that diffusion was going on actively. It is this property of allowing gases to permeate while completely barring liquids that enables cork to be kept in compression under water or in contact with various liquids without air cells becoming waterlogged, and that makes cork so admirable an article for waterproof wear, such as boot soles and hats, for, unlike India rubber, it allows ventilation to go on while it keeps out the wet. The cell-walls are so strong, notwithstanding their extreme thinness, that they appear, when empty, to be able to resist the atmospheric pressure, for the volume of the cork does not sensibly diminish, even when all the air has been extracted. Viewed under very high power, cross-stays or struts of fibrous matter may be distinguished traversing the cells; these, no doubt, add to the strength and resistance of the structure.

From what you have seen, you will have no difficulty in arriving at the conclusion that cork consists, practically, of an aggregation of minute air vessels, having very thin, very water-tight, and very strong walls, and hence, if compressed, we may expect the resistance to compression to rise in a manner more like the resistance of gases than the resistance of an elastic solid, such as a spring. In a spring the pressure increases in proportion to the distance to which the spring is compressed, but with gases the pressure increases in a much more rapid manner; that is, inversely as the volume which the gas is made to occupy. But from the permeability of cork to air, it is evident that, if subjected to pressure in one direction only, it will gradually part with its occluded air by effusion, that is, by its passage through the porous walls of the cells in which it is contained. This fact can be readily demonstrated by the lever press which I have used, for, if the brass cylinder containing the cork be filled with soap and water, and pressure be then applied, minute bubbles will be found to collect on the surface, and their formation will go on for many hours.

On the other hand, if cork be subjected to pressure from all sides, such as operates when it is immersed in water under pressure, then the cells are supported in all directions, the air in them is reduced in volume, and there is no tendency to escape in one direction more than another. An India rubber bag, such as this, distended by air, bursts, as you see, if pressed between two surfaces; but if an India rubber bell be placed in a glass tube and subjected to hydraulic pressure, it is merely shriveled up; the strain on its walls is actually reduced.

To take advantage of the peculiar properties of cork in mechanical applications, it is necessary to determine accurately the law of its resistance to compression, and for this purpose I instituted a series of experiments of this kind. Into a strong iron vessel of 5½ gallons capacity I introduced a quantity of cork, and filled the interstices full of water, carefully getting out all the air. I then proceeded to pump in water until definite pressures up to 1,000 pounds per square inch had been reached, and at every 100 lb. the weight of the water pumped in was determined. In this way, after many repetitions, I obtained the decrease of volume due to any given increase of pressure. The observations have been plotted into the form of a curve, which you see on the diagram on the wall. The base line represents a cylinder containing one cubic foot of cork divided by the vertical lines into ten parts; the black horizontal lines according to the scale on the left hand represent the pressures in pounds per square inch which were necessary to compress the cork to the corresponding volume. Thus, to reduce the volume to one-half required a pressure of 250 pounds per square inch. At 1,000 pounds per square inch, the volume was reduced to 44 per cent.; the yielding then became very little, showing that the solid parts of the cells had nearly come together, and this corroborates Mr. Ogston's determina-

tion that the gaseous part of cork constitutes 53 per cent. of its bulk. The engineer, in dealing with a compressible substance, requires to know not only the pressure which a given change of volume produces, but also the work which has to be expended in producing the change of volume. The work is calculated by multiplying the decrease of volume by the mean pressure per unit of area which produced it. The ordinates of the dotted curve on the diagram with the corresponding scale of foot pounds on the right hand side are drawn equal to the work done in compressing a cubic foot of cork to the several volumes marked on the base line. I have not been able to find an equation to the pressure curve; it seems to be quite irregular, and hence the only way of calculating the effects of any given change of volume is to measure the ordinates of the curve constructed by actual experiment. As may be supposed, the pressures indicated by experiment are not nearly so regular and steady as corresponding experiments on a gas would be, and the actual form of the curves will depend on the quality of the cork experimented on.

The last point of importance in this inquiry relates to the permanence of elasticity in cork.

So far as preservation of elasticity during years of compression is concerned, we have the evidence of wine corks to show that a considerable range of elasticity is retained for a very long time. With respect to cork subjected to repeated compression and extension, I have very little evidence to offer beyond this, that cork which had been compressed and released in water many thousand times had not changed its molecular structure in the least, and had continued perfectly serviceable. Cork which has been kept under a pressure of three atmospheres for many weeks appears to have shrunk to from 80 to 85 per cent. of its original volume

I will conclude this lecture by bringing under your notice two novel applications of cork to the arts.

Before the lecture table stands a water-raising apparatus called a hydraulic ram. The structure of the machine is shown by a diagram on the wall. The ram consists of an inclined pipe, which leads the water from a reservoir into a chamber which terminates in a valve opening inward. Branching up from the chamber is a passage leading to a valve, opening outward and communicating with a regulating vessel, which is usually filled with air, but which I prefer to fill with cork and water. Immediately beyond the inner valve is inserted a delivery pipe, which is laid to the spot to which the water has to be pumped, in this case to the fountain jet in the middle of this pan.

The action of the ram is as follows: The outer valve, which opens inward, is, in the first instance, held open, and a flow of water is allowed to take place through it down the pipe and chamber. The valve is then released, and is instantly shut by the current of water which is thus suddenly stopped, and, in consequence, delivers a blow similar to that produced by the fall of a hammer on an anvil, and just as the hammer jumps back from the anvil, so does the water recoil back to a small extent along the pipe.

During this action, first, a certain portion of water is forced by virtue of the blow through the inner valve, opening outward, into the cork vessel, and so to the delivery pipe, and instantly afterward the recoil causes a partial vacuum to form in the body of the ram, and permits the atmospheric pressure to open the outer valve and re-establish a rush of water as soon as the recoil has expended itself. In the little ram before you, this action, which has taken so long to describe, is repeated 140 times in a minute.

The ram is now working. You hear the regular pulses of the valve, and you see a jet of water rising some ten feet into the air. I throw the electric light on the water, and I ask you to notice the regularity of the flow. You can, indeed, detect the pulses of the ram in the fountain, but that is because I am only using a regulating vessel of the same capacity as that generally used for air, and you will recollect that 44 per cent. of the substance of cork is solid and inelastic. By closing a cock I can cut off the cork vessel from the ram; you see the regularity of the jet has disappeared, it now goes in leaps and bounds. This demonstrates that the elasticity of cork is competent to regulate the flow of water. When air is used for this purpose, the air-vessel has to be filled, and, with most kinds of water, the supply has to be kept up while the ram is working, because water under pressure absorbs air. For this purpose a "sniff-valve" is a necessary part of all rams. It is a minute valve opening inward, placed just below the inner valve; at each recoil a small bubble of air is drawn in and passed into the air-vessel. This "sniff-valve" is a fruitful source of trouble. Its minuteness renders it liable to get stopped up by dirt; it must not, of course, be submerged, and, if too large, it seriously affects the duty performed by the ram. The use of cork gets rid of all these difficulties, no sniff-valve is needed, the ram will work deeply submerged, and there is no fear of the cork vessel ever getting empty. The duty which even the little ram before you has done is 65 per cent., and larger ones have reached 80 per cent.

The second novel application of cork is for the purpose of storing a portion of the energy of the recoil of cannon, for the purpose of expending it afterward in running them out.

The result of the explosion of gunpowder in a gun is to drive the shot out in one direction, and to cause the gun to recoil with equal energy the opposite way. To restrain the motion of the gun, "compressors" of various kinds are used; and in this country, for modern guns, they are generally hydraulic, that is to say, the force of recoil is expended in causing the gun to mount an inclined plane, and, at the same time, in driving a piston into a cylinder full of water, the latter being allowed to squeeze past the piston through apertures, the areas of which are either fixed or capable of being automatically varied as the gun recedes; or else the water is driven out of the cylinder through loaded valves. As a rule, the gun is moved out again into its firing position by its weight causing it to run down the inclined plane up which it had previously recoiled. For naval purposes, however, this plan is inconvenient, because the gun will not run out to windward if the vessel is heeling over, on account of the inclined plane becoming more horizontal, or even inclined in the reverse direction; and should the ship take a permanent list, from a compartment getting full of water, the inconvenience might be very considerable.

In land service guns, when mounted in barbette, the rising of the gun exposes it and the loading detachment more to the enemy's fire; and in both cases, when placed in ports or embrasures, the ports must be higher than if the gun recoiled horizontally, and will therefore offer a better mark to the enemy's fire, especially that of machine guns, while the sudden rise of the gun in recoiling imposes a severe downward pressure on the deck or on the platform.

To obviate these disadvantages, I have contrived the gun carriage a model of which is before you on the table, and a diagram of which on the wall illustrates the internal construction. The gun is mounted on a carriage composed of two hydraulic cylinders, united so as to form one piece. The carriage slides on a pair of hollow ways, and also on to a pair of fixed rams, the rear ends of which are attached to the piece forming the rear of the mounting. There are water passages down the axes of the rams, and these communicate through an automatic recoil valve, opening from the cylinders, with the two hollow slides. There is a second communication between the cylinders and slides by means of a cock, which can be opened or shut at pleasure. The hollow slides are packed full of cork and water, the latter also completely filling the cylinders, rams, and various connecting passages.

By means of a small force pump, enough water can be injected to give the cork so much initial compression as will suffice to run the gun out when the slides are inclined under any angle which may be found convenient.

When the gun is fired, the cylinders are driven on to the rams, and the water in the cylinders is forced through the hollow rams into the cork and water vessels formed by the slides, and the cork is compressed still further. When the recoil is over, the automatic recoil valve closes, and the gun remains in its rearward position ready for loading.

As soon as loaded, the running-out cock is opened, the expansion of the cork drives the water from around it into the cylinders, and so forces the gun out.

If it be desired to let the gun run out automatically immediately after recoil, it is only necessary to leave the running-out cock open, and then the water forced among the cork by recoil returns instantly to the cylinders, and runs the gun out quicker than the eye can follow the motion.

I will now load the model and fire a shot into this strong steel cylinder, at the bottom of which is a thick layer of soft wood. I will close the running-out valve, so that the gun shall remain in the recoiled position. Sir Frederick Abel has kindly arranged some of his electric fuses specially to fit this minute ordnance, and I can fire the gun by means of a small electro-magnetic battery. The gun has now recoiled, and remains in its rear position. I load again, open the running-out cock, the gun runs out, and I fire without closing the cock. You see the gun has recoiled and run out instantly again.

The arrangement I have adopted may be made by using air instead of cork, but air is a troublesome substance to deal with; it leaks out very easily, and without showing any signs of having done so, which might readily lead to serious consequences. A special pump is required to make up loss by leakage.

The merit of cork is its extreme simplicity and trustworthiness. By mixing a certain proportion of glycerine with the water, it will not freeze in any ordinary cold weather.

COMPARATIVE SIZE OF METRIC AND OLD UNITS, WITH REFERENCE TO CONVENIENCE.*

By FRED BROOKS, Member of the Boston Society of Civil Engineers.

THE most useful thing I have to offer to the Society is a table of equivalents, which I will present to begin with, so as to make sure of it. It shows the comparative size of the principal metric and old units, arranged so that approximate equivalents may easily be absorbed by the memory. Three leading units, of length, weight, and bulk, are made conspicuous each as nine-tenths of its metric analogue; and the true relations among the old units are adhered to as far as practicable in the approximate equivalents, so that one equivalent may be associated in the mind with another. For example, the quart being 0·9 of a cubic decimeter, the cubic foot, or 30 quarts, is 30×0·9, or 27 cubic decimeters. Again, the ounce, or weight of $\frac{1}{1000}$ cubic foot of water, is the weight of 27 cubic centimeters of water, or 27 grammes. The approximations that are grouped together generally contain the same percentage of inaccuracy. Values sufficiently accurate for business purposes are added in parentheses.

I desire to supplement this table by a few very simple thoughts and numerous illustrative examples as to the convenience of substituting the metric for the old units.

A real objection to any change of standards of weights and measures is the annoyance of the process of transition; but as most of the opponents as well as the advocates of the metric system declare that some change ought to be made from the existing irregularity of weights and measures, it appears that the annoyance of a transition is unavoidable. The question is: Of what particular change is the annoyance to be preferred? Argument to show that the introduction of the metric system is the change to be preferred has been addressed to the members of this Society and others heretofore; and little argument is now wanted to show engineers the superiority of the metric system, as little is wanted to show them the superiority of railway over mule transportation. Some conservative men will resist any change of standards as long as they live, and they occasionally allege reasons for their resistance. A man does not like to acknowledge that he is too inert to favor a great public improvement; he probably believes, and naturally prefers to say, that he has thoughtfully examined the subject, and finds this or that fatal objection to the proposed improvement. It is amusing to notice how inconsistent with one another are some of the objections alleged against the introduction of the metric system. One engineer thinks the yard and inch can never be superseded by the meter, because it is convenient that bar iron has as many square inches of cross-section as it weighs pounds per yard; while another engineer thinks the yard and inch are to be abandoned, and the foot is to prevail, and therefore he opposes the meter. It is objected, on the one hand, that to take an ideal length of one ten-millionth of the earth's quadrant as the basis of weights and measures, and to abandon all customary metrological units, is too much to be attempted; and, on the other hand, that the metric reform does not go far enough, but that the base of arithmetical notation ought to be changed, and our Arabic system of tens, hundreds, and thousands abandoned. One man declares that the natural way to divide things is by successive bisections into halves, quarters, etc., and he objects to any decimal subdivision of weights and measures; a second man favors the metric units with their decimal subdivision, but finds fault with the length and derivation of the metric names, and proposes to substitute others, calling the decimeter a "*hand*," for example, and the kilo a *bi-pound* or "*bip*;" a third man says the objection to the metric system is that it takes novel magnitudes for its unit-bases, and what he proposes is to decimalize old units, and to adopt the names deci-foot, milli-foot, and centi-milli-foot, similar to metric names. The word *mil* is already used in English writings to signify one-thousandth of an inch.

Leaving these gentlemen to convince each other as best they can of the errors of their respective opinions, I merely remark as a fact that the decimal metric system of weights and measures is evidently coming into use. In pretty much every country in Christendom, changes have been made during the last hundred years for the purpose of introducing decimal systems of coinage, weights, or measures, in place of former irregularity. The movement is still going on, and we may as well prepare our minds for it as for death or for taxation. Let us consider what decimalization amounts to in practice.

1. The successive sub-units that are used in reckoning are limited to such as are in a tenfold ratio to one another, but *an abundant variety of sizes of implements are used in actual dealings under decimal systems*, whether based on the meter or on anything else.

For instance, in this country our dollar is one-tenth of an eagle, and we have a silver coin of five-tenths of a dollar. We always regard it as half of a unit. If we inquire the price of an article, we shall never be told that it is, let us say, seven half dollars, as if this coin were a unit; we may pay seven half dollar coins for the article, but we think of it as three and one-half dollars expense; and nothing in the transaction need prevent us from boasting that our country has a decimal monetary system. Now, reverse the picture. In England, a florin is one-tenth of the pound sterling, and they have a silver coin which is five-tenths of the florin; but they don't think of it as a half-florin; they call it a shilling; they don't name a price of three florins and a half; they say seven shillings. Their money is not decimal, as everybody knows. It might be made decimal.

For another instance, one thousandth part of the

* Read March 3, 1885.

APPROXIMATE EQUIVALENTS.

LENGTH.			
1 inch	and	2½ centimeters	(2.54)
1 foot	"	0.3 of meter...	(.3048)
1 YARD	"	0.9 " METER.	(.9144)
1 rod	"	5. meters.....	(5.029)
1 chain	"	20. "	(20.117)
1 furlong	"	200. "	(201.17)
1 mile	"	1600 "	(1609.3)

AREA.			
1 sq. inch	and	6½ sq. centimeters	(6.451)
1 sq. foot	"	0.09 of sq. meter.....	(.0929)
1 sq. yard	"	0.81 " " "	(.8361)
1 sq. rod	"	25. sq. meters.......	(25.29)
1 rood	"	1000. " "	(1011.7)
1 acre	"	0.4 of hektar........	(.4047)
1 sq. mile	"	256. hektars........	(258.99)

BULK.			
1 cu. inch	and	16⅜ cu. centimeters.	(16.387)
1 cu. foot	"	0.027 of cu. meter...	(.028316)
1 cu. yard	"	0.729 " " " ...	(.7646)
100 cu. feet*	"	2.7 cu. meters.....	(2.8316)
* (The unit of ship's measurement for register.)			
1 M board meas.	and	2⅓ cu. meters....	(2.36)
1 cord	"	3.6 " "	(3.624)
1 U. S. liq. pint	"	0.45 of liter........	(.473)
1 " " " QUART	"	0.9 " LITER......	(.946)
1 " " " gallon	"	3.6 liters.........	(3.785)
1 peck	"	9. "	(U. S. 8.81; Br. 9.09)
1 bushel	"	36. "	(U. S. 35.24; Br. 36.35)
1 ton of ship's displacement	"	1 cu. meter.	

WEIGHT.			
1 grain	and	.06½ of gram	(.0648)
1 troy ounce	"	30. grams	(31.103)
1 avoir. "	"	27. grams	(28.35)
1 pound	and	0.45 of kilo....	(.4536)
60 lbs. (wheat bu.)	"	27. kilos......	(27.216)
80 lbs. (coal bu.)	"	36. "	(36.287)
1 cental.	"	45. "	(45.36)
112 lbs. (cwt.)	"	50. "	(50.8)
1 NET TON	"	0.9 METRIC TON	(.9072)
1 gross ton	"	1. "	(1.016)

COMBINATIONS.				
1 foot-ton (net)	and	0.27 of (metric) ton-meter.....	(.2765)	WEIGHT AND LENGTH.
1 foot-pound	"	0.13⅛ " kilogrameter........	(.13825)	WEIGHT AND LENGTH.
1 pound per running yard	"	½ kilo per running meter......	(.4961)	WEIGHT PER LENGTH.
1 " " " foot	"	1½ kilos " " "	(1.4882)	WEIGHT PER LENGTH.
1 pound per sq. foot	"	5 kilos per square meter.......	(4.883)	WEIGHT PER AREA.
(About 1 atmosphere) 1 net ton " " "	"	1 kilo per sq. centimeter.......	(0.9765)	WEIGHT PER AREA.
(About 1 atmosphere) 15 lbs " " inch	"	1 " " " "	(1.0545)	WEIGHT PER AREA.
1 pound " " "	"	0.07 " " " "	(.07031)	WEIGHT PER AREA.
1 net ton " " "	"	0.14 metric ton per sq. centimeter	(.14062)	WEIGHT PER AREA.
1 pound per cu. foot	"	16 kilos per cu. meter.........	(16.019)	WEIGHT PER BULK.

metric ton on the continent of Europe is the principal commercial weight, called the kilo. A metallic weight of half a thousandth of a ton, or a half-kilo, has, among others, been found very useful in shops. That is decimal just so long as it is treated as $\frac{5}{10}$ of the unit. On the contrary, when, as in Massachusetts, half a thousandth of a ton is a unit, called a pound, and the thousandth part of the ton is not a unit at all, but is two pounds, it is not decimal reckoning. It may be a step toward decimal reckoning, and away from some greater and more ancient irregularity, as the use of the half-kilo as a unit under some name equivalent to the English word pound has been a step toward the introduction of the complete metric system in several European countries. This step was generally taken by a former generation when the metric system was so little introduced as to appear experimental, and when but moderate facilities existed for the dissemination of information among the people, so that a radical change did not appear feasible.

For a third instance, the Gunter chain, used by our grandfathers and still used in many places, is a decimal measure; it is $\frac{1}{10}$ of a furlong, divided into 100 links, and 10 square chains make an acre. Very good. Suppose we make a pole 25 links in length; if we measure off a square with it, that square will contain 625 square links, and be 0·0625 of a square chain. That is decimal just so long as it is treated decimally as a fraction of the unit, the chain, or as a multiple of the sub-unit, the link. Now make the contrary supposition; we call that pole a unit, measure distances with it, and record them as 2 poles and 5 links, or 3 poles and 8 links, etc.; and we call the square pole a *perch*, use that also as a unit, and designate areas as 1 acre and 25 perches, or 2 acres and 30 perches, and the like. Whatever else it may be, this is not a decimal system.

For another instance, most of us use decimal subdivision of the foot and 100 foot tapes, chains, etc., on a certain class of our work. Here is one joint of my leveling-staff, a piece of wood 6 feet long, the feet conspicuously marked 1, 2, 3, etc., and decimally subdivided. If I measure distances with that, regarding it as 6 units, and counting 6, 12, 18, 24 feet, etc., that (be it wise or foolish) is decimal foot measurement; and if I measure a cube having the length of that staff on one side, and figure its contents as 216 cubic feet, that is decimal reckoning. If, on the contrary, I measure distances counting 1 fathom, 2 fathoms, etc., and perhaps reaching such a result as 3 fathoms and 2 feet, or if I measure a cube having the length of that staff on one side, and reckon it as one cubic fathom, I am not adhering to a decimal foot system.

Again, in Texas there are in general use by surveyors to-day chains a little shorter than Gunter's, being 20 *varas* long, with 5 links to a *vara*. If these are always treated as 20 varas and 0·2 of a vara, it is just as compatible with a decimal system based on the vara as a unit as our use of the 20 dollar gold piece or the 2 dollar greenback is compatible with a decimal monetary system. Similarly, the use of a 20 meter chain or a half-meter rule is just as compatible with the decimal character of the metric system as the use of a 2 foot rule or a 50 foot chain would be with a decimal foot system if properly marked and used. My metric leveling-staff is 4 meters long, and might be 5 meters or 3 meters if I chose. In fact, pretty much any size of implement may be used, *provided* it is used as a multiple and not as a sub-unit.

2. The second point upon which I wish to dwell is the very obvious fact that the adoption of a decimal system, wheter based on the meter or on anything else, limits us in reckoning to units that are in a tenfold ratio to one another, and *abolishes reckoning by units of any such magnitudes as several of our ancient customary units.*

Any establishing of standards, such as is now being carried out in a great many kinds of business, means a restriction upon freedom of choice and a forbidding of odd sizes. The adoption of standard time in 1883 meant that different localities and railroads must give up their peculiar time-reckonings, and that all who adopted it throughout the United States of America should be limited to the times of only four meridians separated by intervals of an hour. The adoption of a standard railroad gauge of 4 feet 8½ inches means the abandonment of 6 ft. or 5 ft. gauges, etc. It is similar with standard units of measure. If any man wants to reckon by two units, one of which is twice, or thrice, or four, six, or eight times as large as the other, if he wants to reckon, in feet, the dimensions of the place where his iron bars are to go, and at the same time wants to reckon the weight of the bars by the running yard and their cross-section in inches, then a decimal system on any basis is just what he doesn't want. There have come into use in the past the greatest variety of units of measurement, owing to the different requirements of men, the capricious tastes, negligence, and possibly their dishonesty, so that pretty much every size from small to great has been made a unit by somebody. Scarcely one of these units has a magnitude which is more convenient than some other considerably different magnitude would be for the same purpose; one is used rather than the other merely from custom generally; and it will be a positive benefit to get rid of superfluous units and be restricted to a moderate number of standard units of reckoning decimally related. The feasibility of our dispensing with those to which we have long been accustomed may be better appreciated if we recall the way in which several such units have been disappearing within our own knowledge.

Let us illustrate first with money. On February 22, 1821, Hon. John Quincy Adams, then Secretary of State, made a report to the House of Representatives on weights and measures, to which he gave much study and attached great importance. After referring to the United States having adopted as its dollar or unit the Spanish piece of eight, as it was called, meaning the piece of eight "bits" (to use an American expression for the eighth of a dollar), Mr. Adams said: "Go to New York and offer in payment the Spanish coin, the unit of the Spanish piece of eight, and the shop or market man will take it for a shilling." And again: "For all the transactions of retail trade, the eighth and sixteenth of a dollar are among the most useful and convenient of our coins; and although we have never coined them ourselves, we should have felt the want of them, if they had not been supplied to us from the coinage of Spain." It looks differently in 1886. We don't reckon in shillings, bits, or picayunes; don't coin them; don't use the old Mexican coins, and don't feel the want of them. Our units are of very different magnitude. Similarly, future generations will use a unit of capacity very different in magnitude from our gallon.*

For another illustration, take up the morning newspaper and look at the reports of the London grain market. Quantities of grain are stated in *quarters*, and prices are per *quarter*. The quarter is a measure that was included in the aritnmetics our grandparents studied; but we know nothing about it, yet manage to shift after a fashion with a grain measure of very different magnitude. Likewise our grandchildren may contrive to do business without any measure approaching in magnitude the very numerous *bushels* which now afflict the United States and Canada.

Another unit very frequently mentioned in England is the *stone*, which is a legal weight there. The British Weights and Measures Act, 1878, defines the hundred-weight as 8 stones, and somewhat similar weights with names meaning stone were in use in other European countries before they adopted the metric system. The name is simple and the magnitude apparently convenient, yet in this country we get along just as well without anything like it. A few 14 pound weights are still to be found with old weighing scales, or might perhaps be picked up in junk-shops, but they are called 14 pounds, not 1 stone; and new sets of weights used here don't include one of 14 pounds. In the same way our successors can look in the scrap heaps for our pound weights; we could get along as well with a unit of different magnitude from either the troy pound or the avoirdupois.

Another illustration is furnished by the *pole* (or perch, from the Latin *pertica*, meaning pole), a very old measure, most widely known and significantly named. As to the present use of this unit there is information in the report of the sixth annual meeting of the Ohio Society of Surveyors and Civil Engineers, held in January, 1885. It appeared (p. 120) that of the surveyors present there were five who made it their practice in surveying farm lands to express measures by this unit, six by the foot, and eighteen by the chain. There is, however, no extraordinary convenience in a length of 5½ yards or thereabouts; if the pole were twice as long, or half as long, it would be as convenient for our purposes, and it has in fact varied nearly to that extent at different times and places.† We know that we can express distances perfectly well by a unit of considerably different magnitude, so completely has it disappeared from among us. Our five friends in Ohio may be assured that the loss of the pole by the substitution of a different unit in their work will not be felt as a deprivation after the change shall be fully accomplished.

I have spoken of some units which we dispense with, though they are used elsewhere. There are also units which we use that other people dispense with. One is the American board measure, a superficial foot 1 inch thick. In England they get along without it, using the cubic foot and other units. We could get along, too, without using the foot at all. Another unit used here in Boston is the cubic fathom for earthwork, which we absurdly miscall a "square." In other places, and to some extent here, it is found that a much smaller unit serves as well for reckoning earthwork.

Finally, another unit that has gone out of use is the *league*. Its name is one of the best known among our weights and measures. It is preserved in our literature, used in our legislation, and included in most of our arithmetical tables, the book-makers probably being anxious to round out their tables. They very seldom state its value correctly, but that does little harm, so completely has it disappeared from use as a popular measure. It was a good length for an itinerary measure, as I know from having some experience with a similar measure, the *legua*, still in popular use in Mexico; but we can get along perfectly well without it and with nothing near to the same length in place of it. Likewise we can get along just as well without our outlandish mile by substituting another unit of considerably different size.

In general, our prospect of getting rid of customary magnitudes of units may be judged by our retrospect of having got rid of customary magnitudes of units.

3. The third point upon which I wish to insist is connected with the fact, already stated, that pretty much every magnitude has been heretofore made a unit of measure; the result is that if a decimal system is constructed upon any conceivable base, it would be strange if some of the decimal multiples or sub-multiples did not hit close to the magnitudes of old customary weights and measures. At any rate, *the decimal system founded on the meter*, which is what now concerns us, *has a great many of its units coinciding substantially with old units.* Passing by some such coincidences in the case of the less used sub-units, which, like the eagle and dime in our monetary system, are of very subordinate importance, I will take up the principal metric units one after another, and compare them with old units, interspersing a few comments bearing upon their practical convenience.

The units of capacity can be disposed of very briefly. The principal metric unit of capacity bears the name of *liter*, which is of the same origin as the lb. and £, used to designate the principal British units of weight and value. The *liter* has substantially the same size as the quart, being intermediate between the United States liquid quart, by which milk is measured for every well-regulated family, and the United States dry quart, by which oats are measured for every well-regulated horse. The *hektoliter*, the larger unit of capacity, is of about the same size as the barrel, which is very widely used for dealing in cement, oil, liquors, fish, pork, flour and other products. The name, meaning 100 liters, is analogous to hektograph, meaning 100 copies. Whatever convenience in size is possessed by the quart and the barrel* is possessed likewise by the liter and hektoliter.

Similarly, passing on to weight units, the metric ton is substantially the same as the old ton, being intermediate between the ton of 2,000 pounds and that of 2,240. The *gramme* corresponds to the scruple, previously in use as a medicinal weight, with but little variation in magnitude throughout Europe and America. Its wide diffusion was due to its having come from the *scrupulum* of ancient Rome along with other weights of the same series. The Greek physicians used the name *gramma* instead of the Latin *scrupulum*; thence we have instead of the awkward word scruple our present word *gram*, which has been made very familiar by derivatives like program, telegram, monogram, and diagram.

The *kilogramme* is the principal commercial unit of weight introduced by the metric reform, and it corresponds approximately to what has been used for centuries in the East and in Mediterranean ports.†

A kilo is about the weight that a man can easily manipulate with one hand; hence tools and other articles, like a hatchet, or a pistol, or a bottle of wine, or a volume of United States public documents, are apt to weigh about a kilo; and the Public Statutes of Massachusetts (chap. lx., sec. 3) provide that "a loaf of bread for sale shall be two pounds in weight," which is nearly one kilo.

It remains to discuss linear units. The principal one has the name of *meter*, an old English word sufficiently intelligible to people who define real estate by "metes and bounds." A measuring rod was designated in the Bible and in Shakespeare by the word *meteyard*, now obsolete, in which the syllable yard meant rod. The name *meter* is now given to a length substantially the same that has from time immemorial been the English standard, and has been called a yard or ell. The two names were formerly used indiscriminately. The ancient statute of England, entitled "*Compositio ulnarum et perticarum*," declared that three feet made an ell (*ulna*), and 5¼ ells a perch. Latterly the names ell and yard have been applied to separate measures in the ratio of 5 and 4. The exchequer standard of length constructed in Queen Elizabeth's reign shows both measures upon the same bronze bar by beds or sockets into which the standard yard and standard ell fit; and the colonial legislation of Massachusetts, Maryland, Virginia, and North Carolina (and probably of other colonies) provided for standards of both the ell and the yard.

The Scotch ell was a different measure, which Professor Rankine, in his *Civil Engineering*, says is sometimes found upon old plans. It was 94+ centimeters, or 37 Scotch inches, perhaps arising from throwing in one inch with every three feet. The English ell of 114+ centimeters is regarded especially as a cloth measure. It continued to be included in our school arithmetics down to about the time when the meter was introduced into them. In Heyl's United States Duties on Imports, 1883, a work officially recognized by the Treasury Department, are tables giving superficial measure, weight, and price per lineal yard and meter and also per *aune*, which our dictionaries spell also *auln*, and derive from the Latin *ulna* (el-bow). Silks from Lyons are still imported into the United States in these aunes. This aune is five quarters of a yard, or 114+ centimeters; that is, it is really the English ell. Though it is given by Heyl as a measure of Lyons and Switzerland, it is probably used there only for goods that are to be exported. The old French aune was different; Talleyrand is cited to the effect that in France a hundred years ago there were "18 different legal

* The feasibility of this is more directly shown by the fact that our kindred in Scotland have actually used a unit of very different magnitude; the Scotch gallon prior to the introduction of the imperial measure held 13·66 kilos of water, while the numerous English, Irish, Imperial, and American gallons have held only about 4 or 5 kilos.

† The Irish perch was seven yards, and the acre 160 square perches. In discussing *British and Metric Measures* before the Institution of Civil Engineers, London, Jan., 1885, Mr. Hamilton-Smythe stated that "in Ireland, land purchased for engineering works had to be computed in Irish land measures, the conversions into which were at least as troublesome as the conversion of hectares into statute acres. Sub-contracts for fencing, walling, and even some other kinds of masonry, were in Ireland set in Irish lineal perches, and various local measures had to be used there for purchasing lime, road-metaling, and some other engineering materials." (Van Nostrand's *Engineering Magazine*, Oct., 1885, p. 324.)

The Irish acre, being 7,840 square yards, is 62 per cent. more than our acre (4,840 square yards), and 34 per cent. less than the hektar (which is 11,960 square yards). The use of such a measure in the United Kingdom justifies the inference that in the United States a unit very different from our acre could just as well be used.

‡ As to length, the mile is not conspicuously worse, nor better, than any other itinerary measure; the trouble is that between it and others of our units there is discord. The mile anciently in popular use in England was about half as long again as our present mile; facts about it are imperfectly known, except the fact that there was great confusion. The "old London mile" was 5,000 feet; and in books 5,000 feet was called a "geometrical" mile, which being 303 poles and 2 palms was regarded as incongruous. A mile of 320 poles finally became established, and is called a "statute" mile, because it was incidentally fixed by a statute of Queen Elizabeth. Its awkward relation to our other units is sufficiently accounted for by its being a Roman unit, separated from the other Roman units with which it was most closely connected, and misgrafted upon the English measure. Mile is abbreviated from the Latin *mille passuum* (as kilo is abbreviated from kilogram); and among English-speaking people the length of the mile exhibits some approximation to that of the Roman unit so named; the statute mile, the Scotch mile, the nautical mile, and the Irish mile being respectively about 9, 22, 25, and 39 per cent. longer than the Roman. On the continent of Europe the name was very freely used, and was thrust upon itinerary and geographical measures regardless of length; Denmark still retains its *miil* of 24,000 Rhineland feet, and Russia has in its grand-duchy of Finland a mile of 36,000 Swedish feet. (See Encyclopædia Britannica, ninth edition, vol. ix., p. 218.)

The other nations of Europe have now adopted the metric system, and in several widely separated places the kilometer has been temporarily named *mil*, *mijle*, and *miglio*. If it was an advantage of the Roman mile and the geometrical to bear a simple relation to the artisan's units, the foot and inch; if an advantage of the statute mile, the Scotch and the Irish, to bear a simple relation to the land surveyor's units, his field chain and acre; if an advantage of the nautical mile to bear a simple relation to an arc of the earth's circumference; then it is the superior advantage of the kilometer to bear at the same time simple relations to the artisan's units, the meter and centimeter, to the land surveyor's units, the dekameter and ar, and to the earth's quadrant.

* The following is an extract from the Public Statutes of Massachusetts (chap. lx., sec. 20): "The legal and standard measure of a barrel of cranberries shall be one hundred quarts," etc.

† To go into particulars, various weights, a large number of which were between 800 and 1,300 grammes, have been in use under the name of *rottolo* in some of the Italian cities, Sicily, Malta, Algiers, and Morocco; under the name of *oke* in Ragusa (now Austrian territory), Hungary, Roumania, Servia, Greece, Turkey, Crete, Cyprus, Syria, Egypt, and Tripoli; under the name of *maund* in Arabia; under the name of *seer* in India; and under still different names in a few other Oriental countries. The name of *seer* was given to the kilo by the Act of 1871 providing for its introduction into British India. The name of *oke* was given to the kilo by a decree of the Sultan establishing it in Turkey from March 1, 1882. The name of *mina* was given to the kilo when it was introduced into Greece.

Among the earliest of known weights is the Assyrian *mina*, of about 1,010 grammes, now in the British Museum, as stated in the ninth edition of the Encyclopædia Britannica, vol. xvii., p. 631, under the title *Numismatics*. The late H. W. Chisholm, who was Warden of the Standards, gave it as 998·4 grammes on p. 41 of his *Weighing and Measuring*, published by Macmillan & Co., London, 1877, and he referred to Layard's *Nineveh and Babylon* for further information. *Mina* is akin (and so probably is *maund*) to the Hebrew word *maneh*, which is translated "pound" in the English Bible, I. Kings, x. 17, but meant two or three times as much as a pound. The revised version of the Old Testament, published last year, would have been more accurate if it had translated it "kilo." This everybody may verify by comparing II. Chronicles, ix. 16, and the dictionary definitions of *mina*, *maneh*, and *shekel*. English dictionaries also contain *oke*, to which Webster assigns the same origin as to "ounce," and *seer* is in Worcester. *Rottolo* appears to come from the Arabic for pound.

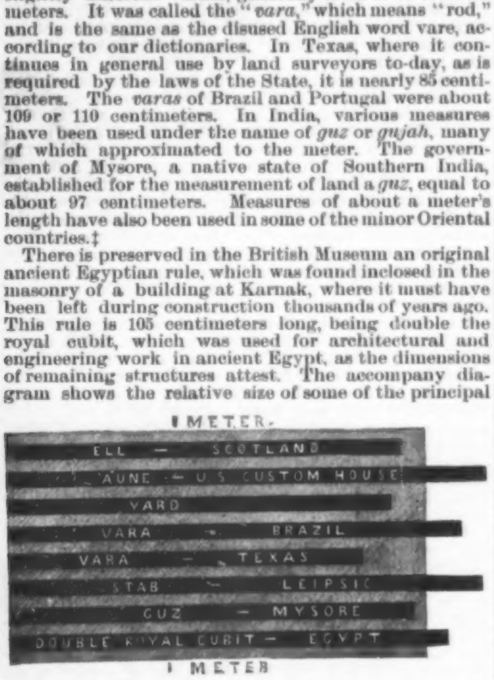
In the ancient series of Scotch weights the *trone pound* (which is imperfectly described by both Webster and Worcester) had somewhat varying values, the largest being nearly 800 grammes. After it was forbidden by law, trone weight continued to be used for butter, cheese, meat, etc.

yards (aunes) measuring $299\frac{58}{100}$ to $597\frac{18}{100}$ lignes."* That is from 67 to 135 centimeters; half way between these two extremes would be 101 centimeters. Various measures approximating to the length of the meter, named *aune*, *stab* (in English, staff), or *elle*, were formerly used in Switzerland, Germany, and Austria. The name of *el* was given to the meter in Holland, and used for fifty years (1821–1870) before the metric names were introduced there. The name of *aune* was similarly given to the meter in Belgium from 1821 to 1836. The name of *stab* was permitted to be given to the meter in Germany from 1868 to 1884, but the permission was not availed of.†

The English yard, equal to 91+ centimeters, is used for general purposes, and among others for distances on land and water, race-courses, range of projectiles, and measurement of paving, plastering, painting, masonry, and earthwork. Engineers also buy their drawing paper by the yard. A recent illustration of its use in the United States is the notice from the Coast Survey Office, published in the newspapers last fall, describing in yards the position of some dangerous shoals in East River, New York. In Great Britain and her colonies the yard is still more freely used than in the United States.

The length unit of Spain and all Spanish America corresponded to our yard, and had in different places slightly different values, generally from 83 to 87 centimeters. It was called the "*vara*," which means "rod," and is the same as the disused English word vare, according to our dictionaries. In Texas, where it continues in general use by land surveyors to-day, as is required by the laws of the State, it is nearly 85 centimeters. The *varas* of Brazil and Portugal were about 109 or 110 centimeters. In India, various measures have been used under the name of *guz* or *gujah*, many of which approximated to the meter. The government of Mysore, a native state of Southern India, established for the measurement of land a *guz*, equal to about 97 centimeters. Measures of about a meter's length have also been used in some of the minor Oriental countries.‡

There is preserved in the British Museum an original ancient Egyptian rule, which was found inclosed in the masonry of a building at Karnak, where it must have been left during construction thousands of years ago. This rule is 105 centimeters long, being double the royal cubit, which was used for architectural and engineering work in ancient Egypt, as the dimensions of remaining structures attest. The accompany diagram shows the relative size of some of the principal

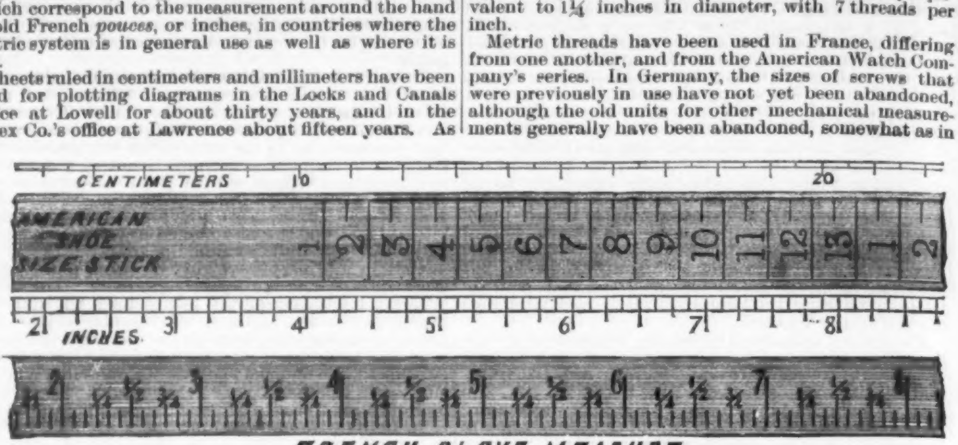


units of length above mentioned. So a measure of about the length of the meter has been used in the most widely separated times and places, and especially in most of the countries and islands washed by the Atlantic Ocean, immediately before the introduction of the metric system; from which at least the negative conclusion may fairly be drawn that there is no marked inconvenience in size about the meter. Whatever convenience in size there is about the yard and these other old measures, there is about the meter. From my observation of the use of such measures for dry goods, and from my own use of the meter for some years in railroad surveying, I draw the positive conclusion that the meter is of convenient length.

The *centimeter*, bearing the same relation to the meter that the cent bears to the dollar, is of about the same magnitude as the barleycorn, which appeared in the statute *Compositio ulnarum et perticarum*, already cited, as if it were the basis of English measures, and which has come down to the present day in our arithmetical tables. Such a length has actually been introduced as a measure in the United States for several special purposes. The shoe stick or measure for the sizes of shoes is marked as shown on the diagram above, where centimeters and inches are drawn adjacent for comparison. The difference between one size and the next, or the unit of size numbering, is but little less than a centimeter, and the difference between a child's size and the adult's size of the same number is a little more than a decimeter, as is also the distance from the end of the measure to the first mark. None of the sizes has an integral number of inches length; and it does not appear why this odd unit of 0·8467 cm., or 0·3333 inch, is established, when the inch is used for the other shoemaker's measurements around the foot, unless it is because especial convenience is found in it. The diagram also shows the graduation of the hat measure, which is applied around the interior circumference of the hat, and determines the numbers, 7, 7⅛, 7¼, etc., which designate the sizes of hats. The intervals between these successive numbers on the measure are almost exact centimeters, as is seen by comparing the scale drawn adjacent; and the distance apart of the units 6 and 7, for instance, or from 6⅜ to 7⅜, approaches a decimeter.

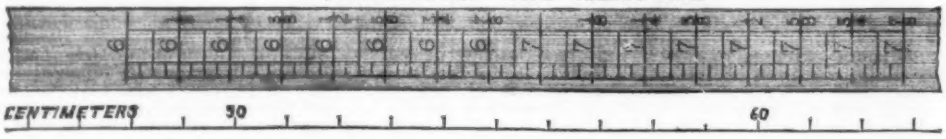
It appears as though there would be in the case of gloves, as well as in that of shoes and hats, an advantage in a unit of the size of a centimeter over a unit so large as an inch, but gloves are in fact sold by numbers which correspond to the measurement around the hand in old French *pouces*, or inches, in countries where the metric system is in general use as well as where it is not.

Sheets ruled in centimeters and millimeters have been used for plotting diagrams in the Locks and Canals Office at Lowell for about thirty years, and in the Essex Co.'s office at Lawrence about fifteen years. As the measurements and work of these companies are in feet and other old units, it would appear that the selection of metric units for their diagrams is because they happen to be convenient in size.



FRENCH GLOVE MEASURE

AMERICAN HAT MEASURE



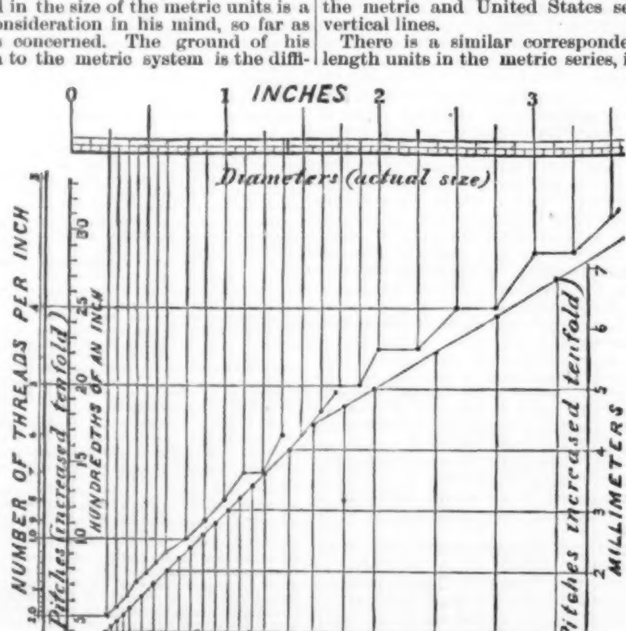
The metric system of measurement was adopted about sixteen years ago by the American Watch Company, at Waltham, Mass., because of its convenience, in spite of their being in the midst of a community that did not use it. The centimeter is their unit. This might serve as a useful hint to people who say, in an unthinking way, apparently, that the meter is too large a unit and the millimeter too small a one for mechanical purposes. In Germany, the millimeter has been chosen as the unit for mechanical purposes, presumably because the Germans are better suited by the smaller unit. In the shops of William Sellers & Co., of Philadelphia, the metric system has been used for some twenty-five years for building injectors. Mr Coleman Sellers said in regard to this in 1876 (Transactions Am. Soc. C. E., vol. v., p. 366): "So we adopted the meter as the unit of measure in this case, and have seen no reason to regret having done so. But its continued use during many years has only confirmed us in the advantage of the inch, a unit which can be divided into any convenient subdivision at the option of the user. The Waltham Watch Factory, or any other manufactory using only short measurements, will find the metric system as convenient as we have found it in its use in building injectors; but for those shops that deal in larger sizes of parts, the inch is very much more convenient." Nov. 4, 1880, he said at the meeting of the American Society of Mechanical Engineers, in his paper referring to the same subject: "Once having perfected an organization in this department, we became fixed in its continuance. Precisely the same reasons why we cannot change our general system into the metric hold against our giving up the metric system in the departments where it is in use." It is plain, therefore, that any inconvenience Mr. Sellers may find in the size of the metric units is a very subordinate consideration in his mind, so far as making injectors is concerned. The ground of his stubborn opposition to the metric system is the difficulty of making a change. W. Sellers & Co. have not introduced metric screw-threads even into their injector department. The machine shop of the American Watch Company uses a series of metric screws of 45 sizes, ranging from 0·05 of a centimeter in diameter, with 100 threads per centimeter, up to 3 centimeters in diameter, with 3 threads per centimeter, which latter, by the way, is not a very small size, being nearly equivalent to 1¼ inches in diameter, with 7 threads per inch.

Metric threads have been used in France, differing from one another, and from the American Watch Company's series. In Germany, the sizes of screws that were previously in use have not yet been abandoned, although the old units for other mechanical measurements generally have been abandoned, somewhat as in France the old numbering of gloves has not been superseded by the metric system, although most articles of clothing are measured in centimeters.

As no uniform metric screw-thread system for ordinary bolts and nuts* has yet been generally adopted even in countries that have adopted the metric weights and measures for other purposes, the desirability of international uniformity, which is a subsidiary reason why we should adopt the metric system for other purposes, is a reason why we should hesitate to adopt it for screw-threads at present. The rivalry of the Whitworth screw-threads, generally used in Great Britain, and the United States standard, generally used in this country, is liable to result sooner or later in drawing attention to the metric threads. The greater delay in introducing metric dimensions in screw-threads than in other things may be attributed to the uncommon difficulty of making any change whatever in them. That it is not due to any want of adaptation of the metric system to screw-threads is seen by comparing tables of metric and old screws. Though as a practical matter it seems a little premature, the comparison may prove an instructive study. As an illustration of the simplicity of the metric system and of its convenience in manufacturing, it will do as well as something more immediately coming into use. The metric series presented in this comparison is substantially that of Delisle, master machinist at Carlsruhe; but it embodies the slight modification made by Professor Reuleaux, of Berlin, who publishes it as useful for technical instruction, though not immediately available for constructive work, in his *Constructor*. (See fourth German edition, Brunswick, 1882, or second French edition, Paris, 1881.)

Let us first consider the selection of diameters of bolts to constitute the standard sizes. This is exhibited at the top and bottom lines of the diagram below, where against the ordinary scales of length the diameters of the metric and United States series are marked by vertical lines.

There is a similar correspondence of diameters to length units in the metric series, in the United States standard series, and in the Whitworth series. In all of these the largest diameters correspond to consecutive subdivisions of the unit of length, and the smallest



* Majority report by Messrs. Coleman Sellers and W. P. Tatham to the Franklin Institute, a copy of which was officially transmitted to the Boston Society of Civil Engineers, Nov. 30, 1876.

† The meter was then thoroughly established in the countries neighboring to Germany, while her own people were remarkably well educated and in possession of great facilities for the dissemination of knowledge; hence it was easy to call the meter by its proper name. In 1821, on the contrary, when the Low Countries adhered to old names, they had some reason; the metric reform then appeared to be an experiment at the best, and in some places a failure; passenger railroads, ocean steamship lines, and the electric telegraph did not exist; and international commerce, the publication of newspapers, and popular education were comparatively insignificant.

‡ Authentic information about Indian weights and measures from 150 different trading places was procured by the East India Company about sixty years ago, and committed to Dr. Patrick Kelly, who published in his *Universal Cambist*.

* An account of the Swiss system of small screws, such as are used in watch manufacture, was given in the report of our Metric Committee, presented March 19, 1884. See *Journal of the Association*, vol. iii., p. 130.

diameters to consecutive smaller subdivisions, while among the intermediate diameters there is less regularity in the spacing, because the intervals want to change without changing abruptly. Both inch and meter measures permit a good series to be made.

Let us next consider the relation of pitch to diameter. The comparison is easily made by looking at the dots on the accompanying diagram, which are plotted by making the diameters abscissas and the pitches ordinates.

It is seen at a glance that the relation of pitch to diameter is regular in the metric scheme and irregular in the United States standard practice. It can be expressed in the metric scheme by simple formulas—

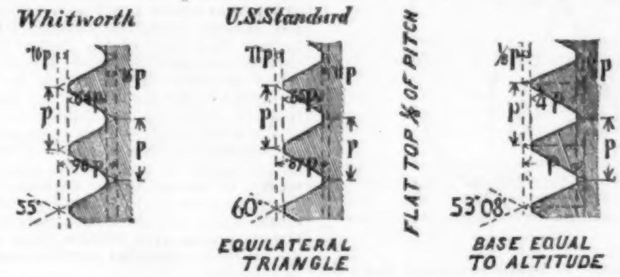
$$\text{Pitch} = 0{\cdot}4\ \text{mm.} + \tfrac{1}{10}\ \text{diameter},$$

and

$$\text{Pitch} = 2\ \text{mm.} + \tfrac{6}{100}\ \text{diameter},$$

according as the diameter is less or more than 40 mm. If intermediate diameter sizes should be required (which is unlikely), they could conveniently have intermediate pitches to correspond according to the same formulas, and not break the regularity of the relation. On the contrary, the United States series admits of no such formula,* and the Whitworth system, though not precisely the same, is in this respect very similar to the United States standard.

The most marked difference between the Whitworth system and the United States standard is in the profile of the thread, as exhibited above.



The Whitworth thread has an angle of 55 degrees, corresponding to a triangle whose altitude is 0·96 time its base; and as one-sixth of this perpendicular distance is rounded off at the root of the thread and one-sixth at the top, the depth of the Whitworth thread is 0·64 time the pitch. The United States standard thread has an angle of 60 degrees, corresponding to a triangle whose altitude is 0·87 time its base; and as one-eighth of this perpendicular distance is cut off at the root of the thread and one-eighth at the top, the depth of the thread is 0·65 time the pitch. The 60 degree angle, being the angle of an equilateral triangle, is more easily established, verified, and adhered to than the 55 degree; and the flat top and bottom are simpler to make than the rounded form. This difference of angle is independent of the unit of length. The United States standard form of thread is just as well adapted to the meter as to the inch; but if it should be adopted for metric screws, Professor Reuleaux would recommend a little greater pitch in proportion to diameter than is shown on the above diagram, so that the formulas would be, if p denotes pitch and d diameter—

$p = 2\,d$ from $d = 4$ to $d = 8$ mm.
$p = 0{\cdot}8 + 0{\cdot}1\ d$ from $d = 8$ to $d = 40$ mm.
$p = 1{\cdot}6 + 0{\cdot}08\ d$ from $d = 40$ to $d = 80$ mm. or more.

The metric scheme on the previous diagram showed everywhere a pitch less in proportion to diameter than the United States standard, because it is intended for a different form of thread. Most other screw systems have a smaller angle than 60 degrees, and Professor Reuleaux prefers the angle (53 degrees 8 minutes) belonging to a triangle whose altitude is equal to its base.

U. S. Standard Bolts.			Metric Bolts and Nuts.								
Outside diameter.	Effective diameter.	No. of threads per inch.	Outside diameter of bolt.	Pitch.	Depth of thread.	Effective diameter of bolt.	Short diameter of hexagonal nut. Finished.	Short diameter of hexagonal nut. Rough.	Washer. Diameter.	Washer. Thickness.	Thickness of bolt-head.
In.	Inch.		mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
....	......	....	4	0·8	0.60	2.60	9	Seldom left rough below 10 mm. diameter.	12	1	3
....	......	....	5	0.9	0.68	3.65	10.5±		14	1	3.5
¼	.185	20	6	1.0	0.75	4.50	12		16	1	4
....	......	....	7	1.1	0.85	5.35	13.5±		18	1.5	5
5/16	.240	18	8	1.2	0.90	6.20	15		20	1.5	6
⅜	.294	16	9	1.3	0.98	7.05	16.5±		22	1.5	6
7/16	.345	14	10	1.4	1.05	7.90	18	21	24	1.5	7
½	.400	13	12	1.6	1.20	9.60	21	24	28	2	8
9/16	.454	12	14	1.8	1.35	11.30	24	27	32	2	10
⅝	.507	11	16	2.0	1.50	13.00	27	30	36	2	11
¾	.620	10	18	2.2	1.65	14.70	30	33	40	3	13
....	......	....	20	2.4	1.80	16.40	33	36	44	3	14
⅞	.731	9	22	2.6	1.95	18.10	36	39	48	3	15
....	......	....	24	2.8	2.10	19.80	39	42	52	3	17
1	.837	8	26	3.0	2.25	20.50	42	45	56	4	18
1⅛	.940	7	28	3.2	2.40	23.20	45	48	60	4	20
1¼	1.065	7	30	3.4	2.55	24.90	48	51	64	4	21
1⅜	1.160	6	32	3.6	2.70	26.60	51	54	68	4	22
1½	1.284	6	36	4.0	3.00	30.00	57	60	76	5	25
1⅝	1.389	5½	40	4.4	3.30	33.40	63	66	84	5	28
1¾	1.491	5	45	4.7	3.55	37.95	70	73	92	6	32
1⅞	1.616	5	......	......	......	......	......	......	......	......	......
2	1.712	4½	50	5.0	3.75	42.50	76	79	100	6	35
2¼	1.962	4½	60	5.6	4.20	51.60	89	92	116	7	42
2½	2.176	4	......	......	......	......	......	......	......	......	......
2¾	2.426	4	70	6.2	4.65	60.70	102	105	132	7	49
3	2.629	3½	......	......	......	......	......	......	......	......	......
3¼	2.879	3½	80	6.8	5.10	69.80	115	118	148	8	56
3½	3.100	3¼	......	......	......	......	......	......	......	......	......
3¾	3.317	3	......	......	......	......	......	......	......	......	......

This has the advantage of ready verification, like the United States standard angle. Taking off one-eighth at the top and one-eighth at the bottom of the thread, he has the depth of the thread exactly three-fourths of the pitch. Hence, if the pitch were the same with this thread as with the United States standard thread, the depth would be a little greater and the strength of the bolt reduced. In order to keep up the effective diameter when the depth of the thread is 0·75 of the pitch, a smaller pitch is required than when 0·65.

The metric screw-threads are given in tabular form below, and with them are put three columns from the table of United States standard threads, which enables comparisons to be made in a little different way from before. It takes more figures to express the nominal diameters and threads per inch in the United States series than the diameters and pitches for the same number of screws in the metric series. The effective diameters in the metric series are mostly exact tenths of a millimeter, and are always expressed accurately and in the same form as the other dimensions. In the United States series, on the contrary, they are regular quantities; they are expressed decimally, while the other dimensions are binary fractions; and they are not exact unless the decimals are carried out to an indefinite number of places. In respect to the other dimensions of the head and nut, there is no important difference between the systems, and those of the United States standard series are not copied in the table. They are easily accessible. Being written in 16ths and 32ds of an inch, they require more figures than the metric dimensions. The formulas are here given. The depth of the nut equals the outside diameter of the bolt in both series.

	Metric.	U. S. Standard.
Depth of head=............	$\frac{7}{10}\,d$	$\frac{3}{4}\,d + \frac{1}{16}$"
Short diameter of finished square or hexagonal nut or head=... .....1 mm.	$+ d + 5\,p$	$1\frac{1}{2}\,d + \frac{1}{8}$"

In February, 1884, in a lecture before the Franklin Institute on *Standards of Length and Their Subdivision*, Mr. Geo. M. Bond explained the exquisite accuracy with which the Pratt & Whitney Company have been making gauges for manufacturing United States standard screw-threads so that bolts and nuts should be interchangeable. He exhibited the standard line-measure bar upon which are ruled the bottom diameters of the United States standard series of threads, and stated that the screw by means of which Prof. W. A. Rogers transferred the graduated lines to this bar was a metric screw. When the railroad companies and bolt manufacturers, in their efforts to get accurate inch standards, resort to a metric screw for the purpose, it would seem to be time for us to learn a little about metric screw-threads.

Metric screw-threads could be cut on lathes with inch divided leading-screws, if that were desired, by the use of a change wheel with 127 teeth; for 127 millimeters equal five inches. In comparisons made with the utmost refinements known to science, there is so slight a variation from that value that it would be imperceptible in the measurements of the machine shop. Professor Rogers found (see Proceedings American Academy of Arts and Sciences, 1882–83) the length of the meter in inches to be 39·37027, according to which 0·127 m. is 5·000024 inches, a variation from 5 inches of less than one part in 200,000.

To sum up, what has been done is to exhibit the magnitudes of many of the principal metric units by comparison with the old units which they are supplanting, and to exhibit some of the evidence which shows the metric units to be of sizes convenient for practical work.

* The formula, $p = 0{\cdot}24\sqrt{D + 0{\cdot}625} - 0{\cdot}175$, sometimes given, is comparatively involved, and it does not perfectly express the relation of pitch to diameter; for instance, a ¾ inch bolt has really 10 threads per inch, but this formula would give 9·4.

GRAPHIC PROCESSES RELATING TO THE LOGARITHMIC SPIRAL.

By Prof. C. W. MACCORD, Sc.D.

It is a well-known property of the logarithmic or equiangular spiral that it is capable of working in pure rolling contact with a similar spiral reversed, each turning about its pole as a fixed center.

In consequence of this, it has many useful applications in mechanism, in cases where a varying velocity ratio is required, forming the contours of smooth reciprocating cams or the pitch curves of lobed wheels whose rotation is continuous.

When used for either purpose, it is usually the case that the lengths of two radiants, and also the angle included between them, are determined by the conditions to be fulfilled, and then the equally familiar property, that the radiant which bisects that angle is a mean proportional between the other two, renders it very easy to find, either by computation or by graphic construction, the lengths of as many radiants as may be desired.

So far then as the determination of points in the required line is concerned, the "laying out" of this curve is executed with great facility. But here the practical difficulties begin, and every draughtsman of experience is aware that the whole family of spirals, simple as they may be to construct, are, in respect to the actual drawing of the line, among the most intractable curves to be found.

Whatever may be the reason, it is an undeniable fact that with the best outfit of "sweeps" or curved rulers, it is not easy to make a perfect drawing of an extended arc of any spiral.

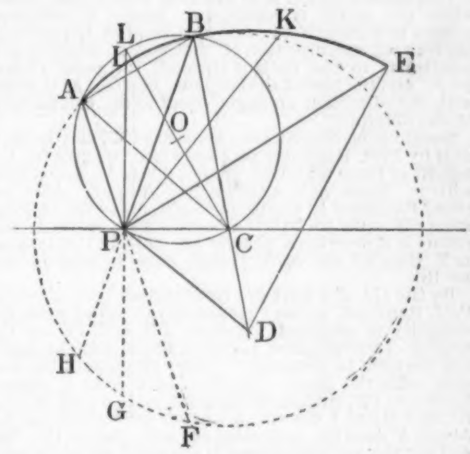
But this is absolutely necessary in practical operations, since the drawing is the sole guide for the workman who builds the machine; and the object of this paper is to show how, in the case of the particular spiral under consideration, this difficulty may be overcome, and the curve drawn as readily as its points are located.

This is accomplished by systematizing the common expedient of finding the centers and radii of circular arcs which differ to an extent practically inappreciable from limited portions of the curve to be drawn. The foundation of the system is the very neat method given by Prof. Rankine, in his "Machinery and Millwork," for finding the center of the circle a portion of whose circumference shall give the closest approximation possible to a given arc of the logarithmic spiral. This is illustrated by Fig. 1, where AB is the spiral arc, AP and BP its limiting radiants, and P the pole. Draw a circle circumscribing the triangle APB, and a diameter thereof, perpendicular to the chord AB, cutting the circumference in L and C: then PL bisects the angle APB, and is cut at I by a circular arc, AB, of which C is the center, making PI a mean proportional between AP and BP; the point I therefore lies upon the spiral.

This is a very simple construction, and gives, as will subsequently appear, a very close approximation to a spiral arc of small extent; but in cases where considerable portions of the curve are to be drawn, it is desirable to avoid the labor of repeating the process.

The manner in which this may be done will be best explained by first giving a demonstration of the correctness of the process itself. Referring still to Fig 1,

FIG 1



complete the circle about center C, as shown in dotted line, and produce AP, IP, BP, to cut its circumference in F, G, and H; then, in the smaller circle, the arc ALB is bisected at L, and the angles APL, LPB, ACL, LCB, standing on equal arcs, are equal to each other, therefore LIPG bisects the angles APB, HPF; and in the larger circle we have

$$AP \times PF = IP \times PG$$

and also

$$PF = PB,$$

and

$$IP = PG,$$

whence

$$AP \times PB = IP^2,$$

as previously enunciated.

Now make the angle CPD equal to the angle APB, and prolong BC to cut PD in D. Then in the triangles APC, BPD, we have the obtuse angles at P, equal by construction, and the angles at A and B are also equal, standing on the same arc, PC, in the smaller circle. These two triangles are therefore similar, whence

$$AP : PB :: PC :: PD;$$

also

$$AP : PB :: AC : BD.$$

Next construct the triangle BDE, similar to ACB, and draw PE; we shall then have

$$AB : BE :: AC : BD :: AP : PB,$$

or:

$$AB : AP :: BE : BP;$$

but the angles PAB, PBE, are equal by construction, consequently the triangles APB, BPE, are similar, whence

$$AP : PB :: PB : PE,$$

and also the angles APB, BPE, are equal, and the point E lies upon the continuation of the spiral arc AB. It will thus be seen that the diagram DPBE is in all respects similar to the original one, CPAB, and that the circular arc BE, which is tangent to AB, will cut PK perpendicular to PD, and bisecting the angle BPE at a point, K, which also lies upon the true spiral.

This process may be repeated indefinitely, as shown in Fig. 2, the angle DPM being made equal to CPD, and PM drawn to cut the prolongation of ED in the point M, which will be the center of the approximating circular arc EQ, the angle EPQ being equal to the angle APB, and so on.

It is not, however, necessary, in fact, to draw and prolong the lines DC, ED, etc., in order to locate the centers D, M, N, etc. For, as above shown, the triangles CPD, DPM, etc., are similar to APB, so that the points C, D, M, N, etc., lie upon a spiral similar to the one to be drawn, and having the same pole, P. Consequently, when the position of the first center, C, has been determined by Prof. Rankine's construction, the lengths of the successive radiants, PD, PM, etc., may be found either by computation or by graphic methods. Nor is it necessary, again, to construct the triangles BDE, EMQ, as set forth in the demonstration, for the purpose of locating the points E, Q, etc., since that operation locates them, as it should do, upon the true spiral, and it is much more convenient to set off at once the exact lengths of the radiants PE, PQ, etc. These may be computed as terms in a geometrical progression, or, if it be preferred to employ graphic processes exclusively, may be very conveniently determined by the method illustrated in Fig. 2; prolong PA and PB indefinitely, and set off PAS = PB; draw through S a parallel to AB, cutting PB produced in T, then PT is the length of the next radiant, PE; set off PU = PT, draw UV parallel to AB, make PQ=PV, and so on.

The same mode of operation, continued in a reverse order toward the pole, enables us to find the lengths of

the diminishing radiants to the left of PA, as shown in the figure; and by a like process we may ascertain the lengths PD, PM, etc., of the radiants of the auxiliary spiral.

We have thus a very simple and easily applied system of locating not only any desired number of points upon the curve, but also the centers of consecutive circular arcs which will pass through them, each one being truly tangent to the ones next in order at the points of junction, and theoretically exact, not only at its extremities, but at one intermediate point; which would seem to satisfy all reasonable requirements in respect to facility of execution in drawing this recalcitrant spiral.

Moreover, we can now determine with great exactness the obliquity or angle included between a tangent and a radiant at any given point; for example, suppose it required to draw the tangent at R in Fig. 2. The length of RZ, now a definite fraction of a circle of known radius, is easily found; with this length as radius, describe a circular arc about R as a center. Set off PZ′ = PZ, on PR produced, and draw a perpendicular to it at Z′, cutting the arc just drawn in the point J: then JR is the tangent required.

This determination is of practical importance, since, when the spiral is required to impart a rectilinear motion to a smooth bar, and also to work in pure rolling contact, the direction of that motion must be perpendicular to the radiant through the point of tangency, and the face of the bar must be so set as to make with that direction an angle equal to the complement of the obliquity.

Should it be desired, the circular arc RZ may be rectified by Prof. Rankine's process, which we give for the benefit of those who may chance not to be acquainted with it. Draw at Z a tangent to this arc; draw the chord RZ, bisect it, and producing it, make the prolongation ZW equal to half the chord; with center W and radius WR describe a circular arc cutting the tangent at X, then XZ will be very nearly equal in length to the arc RZ.

By the aid of a converse construction (also given by Prof. Rankine), we may construct the spiral when the obliquity is assigned. Assume PR and PZ′ as the lengths of two adjacent radiants, whose included angle it is required to determine. Draw through R the tangent, with the given obliquity; at Z′ erect a perpendicular to PZ′, cutting the tangent in J. Set off RY = ¼ RJ, and about Y describe a circular arc with radius YJ. About P describe a circular arc with radius PZ′; this will cut the one first drawn in a point Z, which locates the position of PZ: having then two radiants and their included angle, the curve may be drawn as previously explained.

These two constructions give exceedingly close approximations, provided that the arc to be rectified by the one, or the angle to be determined by the other, does not exceed 30°; beyond which limit indeed it would probably not be desirable to extend the approximating arcs in drawing the curve according to the system above set forth. In the case of the spiral shown in Fig. 2, the angle selected was 22° 30′; and it being of

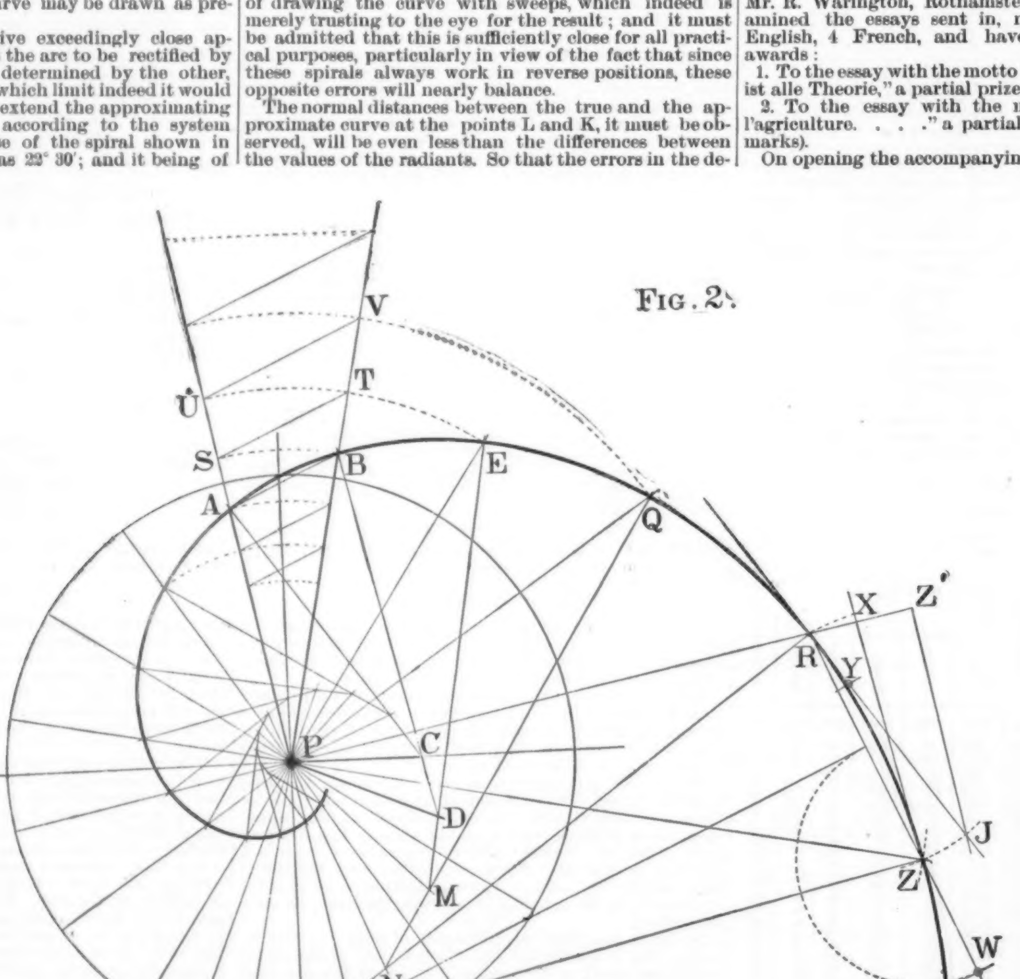


FIG. 2.

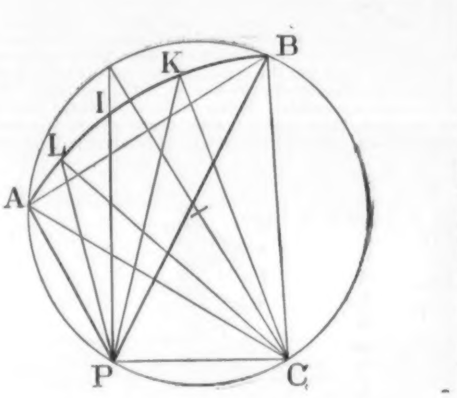
interest to see how close the approximation thus obtained really is, the following test was applied. Referring to Fig. 3, the diagram ABCPI is the same as the part correspondingly lettered in Fig. 1. Proceeding trigonometrically, we solve the triangle APB, in which AP, BP, and their included angle, are given.

Then the angle ABP being equal to PCA, and the side AP and angle APC being known, the solution of the triangle APC gives the values of PC and of AC, the radius of the arc AB.

Now bisect the angles API, IPB; the bisecting lines cut the arc AB at points L and K. In the triangle LPC, we know LC, PC, and the angle CPL, and having similar data in the triangle KPC, these two triangles are readily solved, and the values of PL, PK, as determined by the approximate construction, are ascertained. These values are then to be compared with the precise lengths of the radiants of the true spiral as found by computation.

It is evident that the portion AI of the circular arc must lie within, and the portion IB without, the true curve; and accordingly we find the above trigonometrical value of PL to be a trifle too small, and that

FIG. 3



of PK a trifle too great; it being premised that the value of PB in the spiral as actually laid out was taken at 47, and that of another radiant at right angles to it at 23, the result of this comparison will be as follows:

	Radiant PL.	Radiant PK.
Approximate value..........	41·095	44·959
Exact "	41·106	44·947
	−0·011	+0·012

That is to say, in round terms, that the error is about $\frac{1}{3748}$ length of the radiant. It is doubtful whether any closer work can be accomplished by the usual method of drawing the curve with sweeps, which indeed is merely trusting to the eye for the result; and it must be admitted that this is sufficiently close for all practical purposes, particularly in view of the fact that since these spirals always work in reverse positions, these opposite errors will nearly balance.

The normal distances between the true and the approximate curve at the points L and K, it must be observed, will be even less than the differences between the values of the radiants. So that the errors in the determinations of the obliquity and of the length of the arc are very minute, as given below:

	Length of Arc AB.	Obliquity.
Approximate value......	18·5693	65° 32′ 12″
Exact "	18·5691	65° 32′ 10″
	+0·0002	+0° 0′ 02″

The obliquity, then, is too great by 1-117965 of the true angle, and the arc by 1-92845 of the whole. The latter excess is the measure of the amount of sliding between such a spiral sector and a smooth bar tangent to it, and lifted by it in a direction perpendicular to the radiant at the point of contact, while the former measures the error in determining what that direction should be; and it need hardly be pointed out that these discrepancies are far within the limits of unavoidable errors in workmanship. When two sectors work together as rolling cams, the amount of sliding introduced by the substitution of the approximating circular arc, it may be safely inferred, will be still less than that given above, inasmuch as both will have errors of excess, presumably very nearly equal in magnitude; which tend to neutralize each other, by making the acting curves of the same actual length.

So much for the theoretical error of the geometrical method; but the question may be asked, How closely can the instrumental execution be expected to agree with these calculated results? Probably the most rigorous test of the accuracy of the work is the measurement of the obliquity as determined by the construction, since the drawing of the tangent involves all the sources of error in the whole process, including the graphic rectification of the arc, which last does not enter into the above computation. Now, the original diagram from which Fig. 2 is reduced was drawn without any special care, the radiant PR representing 35¼ inches, on a scale of 1½ inches to the foot; and by careful measurement with a protractor, the obliquity, which as above stated should be 65° 32′ 12″, was found too great by about 12′ 30″; the discrepancy amounting to 1-315, or a little less than one-third of one per cent. of the whole angle. This, certainly, may be regarded as reasonably close, when it is remembered that the actual length of the line XZ, upon which the determination of the obliquity depends, is only 2·069 inches; and it may be fairly concluded that graphic operations alone upon a little larger scale will, with due care in the execution, give results quite accurate enough for all ordinary practical applications of this curve in mechanism.

RESULTS OF THE NITRATE OF SODA PRIZE.

CARRYING out the scheme of prizes offered by the Committee of the Saltpeter Producers' Association (Comite Salitero at Iquique, Chili) for the best popular essay treating of the importance of nitrate of soda as a manure, and the best mode of its application, the judges—Prof. L. Grandeau, Nancy (France); Prof. Adolf Mayer, Wageningen (Holland); Prof. A. Petermann, Gembloux (Belgium); Prof. G. Thoms, Riga (Russia); Prof. Paul Wagner, Darmstadt (Germany); Mr. R. Warington, Rothamsted (England)—have examined the essays sent in, namely, 13 German, 13 English, 4 French, and have made the following awards:

1. To the essay with the motto "Grau, theurer Freund, ist alle Theorie," a partial prize of £350 (7,000 marks).

2. To the essay with the motto "Pour pratiquer l'agriculture. . . ." a partial prize of £150 (3,000 marks).

On opening the accompanying envelopes, the author of the first essay was found to be Dr. A. Stutzer, principal of the agricultural experimental station at Bonn; and the author of the second essay, M. A. Damseaux, professor in the agricultural academy at Gembloux.

It should be remembered that essays competing for the second part of the prize offered—namely, £500 for the best essay treating of the same subject, on the basis of *new, personal, experimental investigations*—must be sent to one of the above named judges on or before January 1, 1887.

On behalf of the Comite Salitero,

P. WAGNER.

ON THE SOUNDS PRODUCED IN A METALLIC DISK OR CORD BY ELECTRIC DISCHARGES.

By Prof. E. Semmola.

It is well known that an alternating electric current which is traversing a taut metal cord sets the latter in vibration, and thus produces a sound; and the same is the case with a wire when it is rapidly magnetized and demagnetized.

We have the same phenomenon likewise when a body is submitted to the discontinuous action of heat, or to the more delicate and feebler one of light. On considering this kind of phenomena, I asked myself whether the same effect ought not to be produced by the discontinuous action of electric discharges.

Experiment decided in my favor, and, unless I am deceived, the phenomenon exhibited itself just as I had imagined it would. The sounds may be emitted either by a disk or a cord under the action of an electric discharge, directly or by induction.

I proceeded as follows:

Sounds Produced by Direct Discharge.—From one of the conductors (Fig. 1)—the arc, for example, that ends

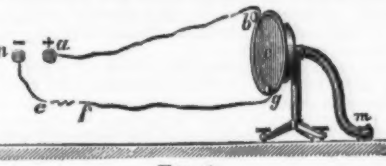


Fig. 1.

at the positive pole of a Holtz machine—starts a copper wire sixteen feet in length, which, at the other extremity, is affixed to a terminal, *b*, soldered to a disk, *c*, of brass, about 0·02 in. in thickness and completely insulated.

A second wire, fixed to the other terminal, *g*, puts the disk in communication with the negative conductor, *n*, of the machine, and thus serves to close the circuit. At a very short distance from the terminals, *n* and *a*, the circuit is interrupted at *e f*, and it is here that the spark occurs when the machine is set in motion.

The disk, *c*, is fixed to the ebonite mouthpiece of a speaking tube that terminates in an ear trumpet, *m*.

Upon revolving the disk of the machine, frequent sparks occur at the point where the circuit is interrupted, and a continuous sound is heard by the person who applies his ear to *m*.

It may naturally be asked, in the first place, whether the sound emitted was not produced by the spark, and transmitted through the intermedium of the conductor. In answer to this, I shall observe that the room in which the sound was perceived was contiguous to the one in which the machine was placed, and that, as soon as the door was closed between the two, it was no longer possible to directly hear the noise made by the spark. In order to remove all doubt, I first interposed in the circuit, *f g*, a coarse lead wire, and afterward a Geysler tube, without preventing the sound from being distinguished perfectly.

I went still further. I suppressed the return wire, which might especially have been suspected of transmitting the sound. The arrangement adopted is shown in Fig. 2. The terminal, *g*, and consequently the disk,

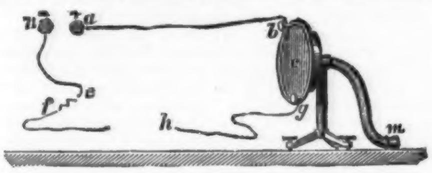


Fig. 2.

c, here communicated directly with the ground, without interruption, and the spark occurred afar off, at *e f*, between the negative conductor and a small metal chain placed upon the ground, so as to facilitate communication with the earth.

Even upon adopting this arrangement, the sound emitted by the disk was very distinctly heard.

Although this experiment was, of itself, convincing enough, I was desirous of removing the least doubt as to the origin of the sound, and therefore substituted, at *f*, for the chain, a vertical cogwheel, against the circumference of which bore the extremity, *e*, of the conductor. The electric machine was left at rest, and the wheel was revolved very slowly. The free extremity of the wire rubbed between the teeth, and produced a sound as in the Savart wheel, and the intensity of which was greater than that of the sound produced at the same point by the spark; nevertheless, the communication being always established, not the least noise was heard at *m*.

It seems to me, then, beyond a doubt that the sounds which I distinguished in the preceding experiments were due to a certain special motion produced in the molecules of the disk, *c*, by the frequent electric discharges traversing it.

If the end, *b*, of the wire, instead of being fixed to the terminal, *b*, as before, is kept at a short distance from *c*, so that the sparks occur between the wire and disk, the sound becomes louder, and we very well distinguish the noise that the spark produces from the sound emitted by the disk.

So, too, if the wire be sufficiently separated from the disk to no longer give any spark, but only that luminous electric flux that we observe when a discharge of high tension is produced with difficulty between the small projections or rugosities of the conductors, the sound is again very well distinguished, although it is feeble.

The sound increases a little bit in intensity when we place the tripod that supports the disk upon a sonorous box. The sounds thus emitted recall those of the siren or of the Froment interrupter, and become sharper on revolving the machine faster. It results from this that if the disk of the machine be given a very great velocity and then be left to itself, so that it may gradually revolve more slowly and slowly until it stops, the sounds at *m* will gradually grow weaker, as in an acoustic siren when the velocity of the current of air is diminishing. The sound likewise changes tone when the length of the sparks is varied, and becomes naturally sharper in measure as the latter are shorter. Upon using a wooden disk instead of a metallic one, we obtain a sound of special character.

I have not yet been able to obtain any traces of nodal lines, even on powdering the disk with lycopodium.

Sounds through Induced Discharges.—In order to obtain sounds under the action of induced discharges, which, in my opinion, ought to present a greater interest, I arranged the apparatus as in Fig. 3.

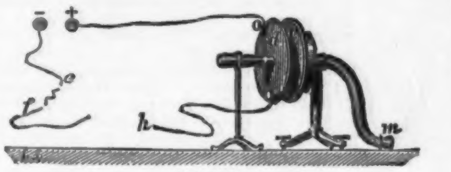


Fig. 3.

In the primary circuit of the machine there is a brass disk, *d*, standing vertically and supported by an insulating stand. This disk, which is of the same dimensions as the one usually employed, is placed parallel with and at a few fractions of an inch from *c*, which, as before, is fixed to the extremity of the sonorous tube.

As soon as the machine is set in motion, sparks occur at *e f*, and the sound is at once perceptible to the person who applies his ear to *m*, although the disk, *c*, is not being traversed directly by the electric discharge. Upon making the induced disk, *c*, communicate with the earth, the sound becomes much louder, and its intensity even increases a little when a pane of glass is interposed between the two disks.

When the extremity, *e*, of the conductor is placed upon the ground, so that no spark is any longer produced in the primary circuit, the sound becomes feeble. This I believe to be due to the fact that in this case the disk, *c*, always remains influenced too, and that there no longer exists any discontinuity in the action of induction—the necessary element for the production of the phenomenon.

By the same method, sounds may be evoked from a metal cord. It suffices to substitute for the disk, *c* (Fig. 2), a steel cord held taut upon the sonorous box of a sonometer, from which it is insulated.

As soon as the machine is set in motion, the cord becomes the seat of electric discharges, and produces a sound which is so feeble that, in order to distinguish it, it is not enough to place the ear very close by. On the contrary, the sound can be heard very distinctly by proceeding as in the preceding experiments, that is to say, by employing an ear trumpet that communicates with an ebonite collector, whose mouthpiece is applied to the upper surface of the sonorous box.

The sounds obtained with metallic cords are more agreeable to the ear, and have a more musical character, than those given by disks.

I shall soon occupy myself with the manner in which the tonality of these sounds varies when the dimensions, quality, and degree of tension of the cords is varied. I propose, likewise, to show how their intensity may be increased by the use of a microphone.—*La Lumiere Electrique.*

ALUMINUM.

If the modern metallurgist ever indulges in day dreams like those of his predecessor, the alchemist, and pictures himself possessed of a spell powerful enough to subdue the most stubborn chemical affinities, surely it must be on aluminum that his mental gaze fixes itself at such times. An ample supply of that metal would utterly transform all engineering, and might even remodel the conditions of our life. The mind might dwell for days upon the changes which would be effected by the introduction of a tenacious structural material of one-third the specific gravity of iron, without being able to grasp them fully. What a revolution it would effect in naval architecture; how the spans of our bridges would increase, and what a growth there would be in the power of the engineer to attack difficulties which now seem impossibilities! But the qualities of strength and lightness are not all that aluminum has to recommend it. It has a low melting point, about 1,000 deg., and not only can be cast with facility, but it works well under the hammer. It will not oxidize even at a red heat, and will resist all acids except hydrochloric. It will alloy with most metals, and in so doing lends them a large share of characteristics. It is a capital conductor of electricity, and, indeed, seems to combine in itself all the good qualities of all other metals.

At present an unlimited supply of pure aluminum at a low price is still a dream, but as events march we might any morning awake to find it a reality. For some time it has been produced in England by Webster's Aluminum Crown Metal Company, of Birmingham, at the price of 60s. per pound, and now alloys of aluminum are being sold in America on the basis of $3.80 per pound for the contained aluminum. Even the latter price is, of course, prohibitive for employment of the pure metal for most uses, but it is admitted by the manufacturers that at an early date a heavy reduction will be made, and then we shall see its rapid introduction. But although aluminum is for the present commercially unattainable, its alloys are already in the market, and bid fair to displace all the bronzes and brasses. One form has already been described in these columns under the name of mitis castings. These, it will be remembered, are castings made from wrought iron melted in a petroleum furnace. The secret of the success of the process lies in the addition of from 0·05 to 0·1 of 1 per cent. aluminum to the molten metal. This has the effect of suddenly lowering the melting point of the mixture by 300 deg. to 500 deg., and thus, without superheating the metal in the furnace, it is rendered exceedingly fluid, and becomes immediately furnished with a store of surplus heat, which enables it to run into moulds and fill them perfectly. Recently a leading steel maker of America, wishing to test the system, made two castings on this plan, welded them together, and then drew them into wire, which exhibited a breaking strain of 90,000 lb. per square inch. This result showed that not only was the original quality of the iron preserved, but that it had actually been improved by melting and the addition of the aluminum.

Another important alloy is made with copper, nine parts of the latter to one of aluminum. This will work hot under the hammer, and can be spun, rolled, and wire drawn with great facility. Under the latter condition its tensile strength will run up to 200,000 lb. to the square inch, while in rolling the greater toughness of the metal more than compensates for its higher price. Castings made from this mixture have a fine golden color, which is permanent, and have a tensile strength of 100,000 lb. to the square inch. When the proportion of aluminum is lowered to 5 per cent., the tensile strain is reduced to 68,000 lb. per square inch, and even with but 2 to 3 per cent. of aluminum, the alloy is stronger than brass. Another alloy, called Hercules metal, is composed of copper, nickel, and zinc, with a small percentage of aluminum, and this has withstood a strain of 105,000 lb., breaking without elongation.

The great decrease in the price of aluminum is due to the introduction of the electric furnace. This was invented by Sir William Siemens, but his death prevented him from bringing it to perfection. In America the matter was taken up by Messrs. Eugene H. and Alfred H. Cowles, and by its aid they have succeeded in reducing refractory ores, which have hitherto resisted the action of the most intense heat attainable. Among these is alumina, which, with the exception of silicon and lime, is the most common constituent of the earth's crust. It occurs in 195 different species of minerals, and, when combined with oxygen and silicon, forms clay. Its richest ore is corundum, which is 54 per cent. of metallic aluminum and 46 per cent. of oxygen. Till 1869 the only sources of this mineral were a few river washings in India, and it cost from 6d. to 1s. per pound. But in that year Mr. W. P. Thompson found in Northern Georgia an inexhaustible mine of corundum in the Crysolite Serpentine, and many other sources have been since discovered. Its present value at the mines is 2*l.* a ton, and the cost of the ore at the works is about 4*l.* per ton of metal. In Europe, where the process is being introduced, it is probable that manufacturers will look to using alumina, artificially prepared from cryolite, or from Kynaston's sulphate of alumina.

We will now describe the furnace used by Messrs. Cowles in the reduction of alumina. It consists of a horizontal trough 12 in. wide, 15 in. deep, and 5 ft. long. This is built of firebrick; but as this material will run like water under the intense heat, it requires to be lined with a more refractory substance. This is powdered charcoal, which has never yet been known to be fused. But although it will not soften, yet, in the early experiments, it was found to suffer a molecular change, and to be transformed into a kind of graphite. In this condition it is a fair conductor of electricity, and allows the current to traverse it, a condition of affairs which is undesirable. To prevent this, the charcoal powder is washed in lime water and then dried; thus each particle is surrounded with a fine coating of lime, which acts as an insulator. The bottom of the trough is spread with charcoal powder, and then, by the aid of temporary sheet-iron partitions, a lining of the same material 2 in. thick is built up against each side wall. Through the end walls there enter carbon electrodes 3 in. in diameter and 30 in. long, and these are pushed forward until they meet within a short distance. Around them the charge is packed in. It consists of about 25 lb. of the oxide of aluminum, 12 lb. of charcoal and coarse carbon, and 50 lb. of granulated copper. In place of the granulated copper, a series of short copper wires or bars can be placed parallel to each other and transverse to the furnace. When this is complete, a layer of coarse charcoal is placed over the charge, and an iron lid, lined with firebrick, with a few apertures for the escape of gas, is luted down on the top of the furnace.

The furnace is now ready for the current to be turned on. This is produced by Brush dynamos, and at its maximum equals 1,300 amperes with an electromotive force of 50 volts, or about 90 electrical horse power. In order to regulate it, a resistance coil of German silver, inserted in a trough of water, is placed in the circuit, and can be switched in and out by sections. At first a considerable portion of it is inserted, in order that the current may be started gently. By means of an ammeter the attendant knows what current he has, and he adjusts the electrodes and resistance accordingly until the desired conditions are attained. In about ten minutes the copper between the electrodes is melted, and the latter are moved farther apart, and the current increased to its maximum. For five hours the heat is maintained, and during that time the corundum is gradually reduced, the oxygen being taken up by the carbon, and escaping as carbonic oxide. The copper, which boils and bubbles on the floor of the furnace, combines with the aluminum, and protects it from union with the carbon, which would otherwise take place. By the time the entire charge is spent, the electrodes have been moved backward until the greater part of the furnace is exposed to the action of the current. The process is then complete, and the current is diverted to another furnace. The leads are not connected directly to the carbons, but to copper boxes through which they pass. Each box has its vacant space filled with copper shot, which form numerous points of contact for the current to reach the carbon, and serve to conduct away the heat from the glowing electrode when it is being withdrawn.

The copper is found, on analysis, to contain 15 to 30 per cent. of aluminum and a little silicon, and is melted with a further proportion of copper to produce an alloy of the required character. Up to the present it has not been found possible to produce pure aluminum, but hopes are entertained that at the new works, which are being erected, this will be done. These will be situated at Lockport, New York, and have ample water power. Twelve new dynamos are being built for them, and it will be possible to concentrate 1,200 horse power of electrical energy within one furnace there.

Other metals, such as boron, sodium, potassium, calcium, magnesium, chromium, and titanium, have all been reduced from their oxides by means of carbon in this furnace, and the first of these has a very marked

effect upon copper, increasing its strength to 50,000 lb. or 60,000 lb. per square inch, without diminishing its conductivity. Another metal which can be obtained is silicon. This is largely used on the Continent in the manufacture of telephone wire, and, like boron, gives great additional strength to the metal. What will be the ultimate effect upon chemical science of the introduction of the furnace it is impossible to say, but it promises to be a key to a crowd of difficulties which have hitherto resisted all attempts at solution. A furnace is being erected by Messrs. Allan & Co., at the American Tool Works, Antwerp; and if the prognostication of Messrs. Cowles that aluminum can be sold at 30d. per pound be fulfilled, it will require hundreds of works to supply the demand. At this price aluminum would be as cheap, bulk for bulk, as copper at 6½d. per pound, while there is scarcely a purpose for which it is not superior. As a conductor of electricity it would replace galvanized wire at once, and in all culinary and domestic purposes it would be cheaper and better than either tin or copper. It is impossible to run through the entire list of purposes to which aluminum is applicable, but two which suggest themselves most naturally are torpedo boats and dirigible balloons. In the former, every ounce of weight is considered, and cost is of no moment compared with speed. What a change would be wrought in the design and construction of those vessels if the weight of the engines, boilers, hull, or fittings could be reduced by two-thirds! As to balloons, no one would dare to speak confidently; but if the problem of aerial flight is ever to be solved, it is probable that the introduction of aluminum will be the chief agent in the matter. For the present, we must wait to see if the promise of pure aluminum at a cheap rate will be fulfilled, and when it is, we shall enter on a new stage of the material development of the world.—*Engineering.*

DECOMPOSITION OF AMMONIA BY ELECTROLYSIS.—A LECTURE EXPERIMENT.

By the Rev. A. IRVING.

AT the present moment, when electrolytic processes are receiving so much attention, it is worth while, perhaps, to draw attention to the following experimental demonstration of the proportion in which hydrogen and nitrogen gases separate out from ammonia. So far as I am aware, it has not as yet found its way into any English text-book of chemistry; but its extreme simplicity and its manageability render it peculiarly suitable for lecture demonstrations, while it has also a special interest as illustrating those *secondary actions* which take place in electrolysis in many cases. The experiment is not original, and I am indebted for it to Prof. Wislicenus, of Wurtzburg, of whose excellent "Lehrbuch"* I have made very free use for some years past.

An ordinary three-tubed voltameter of Hoffman's form, such as is commonly used for the electrolysis of water, is so modified in its construction as to have two carbon pencils of the material used in the ordinary Bunsen cell introduced to serve as electrodes, one at the bottom of each of the two tubes, which are furnished at the top with stop-cocks; the carbon pencils being inserted through corks, which plug the tubes, and are made to carry platinum wires for connection with the conducting wires of the battery.

The actual electrolyte is a concentrated solution of sodium chloride, and with this is mixed about one-tenth of its volume of the strongest solution of ammonia. By the substitution of carbon for platinum, the action of the nascent chlorine upon that metal, which would vitiate the results, is obviated.

In a few minutes, with a fairly strong battery (4 to 6 Bunsen or Grove cells), a considerable volume of each of the gases N_2 and H_2 is liberated in the separate tubes, the volume of the latter being three times that of the former, and these are tested in the usual manner.

The following scheme may be taken as accurately representing what goes on:

− Pole	6NaCl	+ Pole
$6Na + 6H_2O = NaOH + 3H_2$		$6Cl + 2H_3N = 6HCl + N_2$

The HCl is of course fixed by some of the undecomposed ammonia ($6NH_3 + 6HCl = 6NH_4Cl$), and, remaining in solution as NH_4Cl, does not interfere with the volumetric results.

It will be seen that nothing is assumed here but—

1. The axiom that things which are equivalent to the same thing are equivalent to one another.
2. The known reaction of sodium on water,

$$Na_2 + 2H_2O = 2NaOH + H_2.$$

3. The equally well known reaction of chlorine upon ammonia, $3Cl_2 + 2NH_3 = 6HCl + N_2$.
4. The law of Avogadro.

Upon these the following train of reasoning is based without much difficulty:

Starting with the decomposition of the NaCl, and confining our attention at first to what takes place at the negative pole, where Na is removed from the salt and where the free H_2 appears, we know that for every three molecules (or six atoms) of H_2 set free, $6H_2O$ has undergone decomposition; from the known composition of NaCl and known electrolytic laws we know that the removal of 6 atoms of Na at the cathode must be accompanied by the release of 6 atoms of chlorine at the anode; and from the known composition of HCl (the only known compound of these two elements) we know also that these 6 atoms of chlorine must take up 6 atoms of H, the equivalent of the 6 atoms ($3H_2$) liberated at the cathode; and from these 6 atoms of H in the ammonia, two atoms (1 molecule) of N_2 are set free, as seen in the experiment.

It need scarcely be added that, for the demonstration of the proportion which a given volume of NH_3 bears to the sum of the volumes of the N_2 and H_2 produced by its decomposition, under the same physical conditions, the decomposition of the dry gas by the spark stream in a eudiometer over mercury is as necessary as ever.—*Chem. News.*

* "Lehrbuch der Anorganischen Chemie," § 147.

A LECTURE EXPERIMENT FOR SHOWING THE COMPOSITION BY VOLUME OF NITROUS AND NITRIC OXIDES.

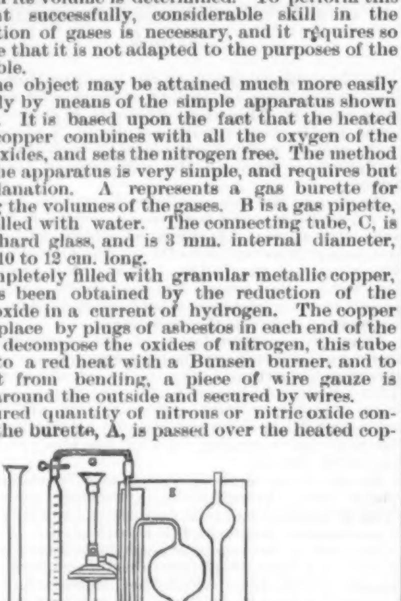
By E. H. KEISER.

THE usual method of showing that nitrous oxide contains its own volume of nitrogen, and that nitric oxide contains half its volume of nitrogen, is to decompose these gases by bringing them in contact with heated potassium. For this purpose, a quantity of the gas to be examined is collected in a eudiometer over mercury, and its volume is determined. The gas is then transferred to a bent glass tube closed at one end, and a small piece of potassium is introduced into the bent portion of the tube by passing it up through the mercury by means of a wire. The lower and open end of the tube is now closed under the mercury with the finger, and the part of the tube containing the potassium is heated with the lamp. After the combustion the tube is allowed to cool. The gas, which now consists of nitrogen, is transferred back again to the eudiometer, and its volume is determined. To perform this experiment successfully, considerable skill in the manipulation of gases is necessary, and it requires so much time that it is not adapted to the purposes of the lecture table.

The same object may be attained much more easily and rapidly by means of the simple apparatus shown in the cut. It is based upon the fact that the heated metallic copper combines with all the oxygen of the nitrogen oxides, and sets the nitrogen free. The method of using the apparatus is very simple, and requires but little explanation. A represents a gas burette for measuring the volumes of the gases. B is a gas pipette, which is filled with water. The connecting tube, C, is made of hard glass, and is 3 mm. internal diameter, and from 10 to 12 cm. long.

It is completely filled with granular metallic copper, which has been obtained by the reduction of the granular oxide in a current of hydrogen. The copper is held in place by plugs of asbestos in each end of the tube. To decompose the oxides of nitrogen, this tube is heated to a red heat with a Bunsen burner, and to prevent it from bending, a piece of wire gauze is wrapped around the outside and secured by wires.

A measured quantity of nitrous or nitric oxide contained in the burette, A, is passed over the heated cop-



per by opening the pinch-cock and raising the reservoir tube of the burette. When the reservoir tube is lowered, the gas is drawn back from the pipette. It consists of nitrogen, and its volume may be readily determined. If nitric oxide has been used, the volume of nitrogen obtained will be exactly one-half the original volume of the gas, while in the case of nitrous oxide the volume of nitrogen will be the same as the volume of nitrous oxide taken, although the copper will have been oxidized and the gas will have lost its power of supporting combustion. The error rarely exceeds 0·1 per cent. in the case of nitric oxide, while with nitrous oxide equally good results are obtained if the water in the burette has been previously saturated with the gas.

It is of course necessary to have the oxides of nitrogen free from air. The burette may be conveniently filled with pure nitric oxide as follows: Into a flask of about 300 c. c. capacity there is placed a mixture of 100 grms. of ferrous sulphate and 12 grms. of potassium nitrate. To this is added a quantity of dilute sulphuric acid, obtained by mixing 60 c. c. of the concentrated acid with 160 c. c. of water. The flask is closed with a one-hole rubber stopper, through which passes a glass tube bent at right angles. On heating the mixture contained in the flask, pure nitric acid is evolved. A T tube is then attached to the gas burette, and one of its branches is connected with the outlet tube of the flask. The air in the burette is expelled by opening the pinch-cock and raising the reservoir tube until water flows out of the open end of the T tube. After all the air has been expelled from the generating flask, the open end of the T tube is closed with a rubber tube and pinch-cock, and the gas allowed to pass into the burette.

The same apparatus serves for filling the burette with nitrous oxide, the gas in this case being made by heating pure ammonium nitrate.—*Am. Chem. Jour.*

COMBUSTION OF CARBONIC OXIDE AND HYDROGEN.

(1.) *Action of Steam on Carbonic Oxide.*—In 1880, Dixon showed that a mixture of dry carbonic oxide and oxygen is not exploded by the electric spark, the presence, however, of a minute trace of water or of a hydrogenous volatile body being sufficient to determine the explosion. He proposed the hypothesis that the steam acts the part of a "carrier of oxygen," by undergoing alternate reductions and reformations, thus (i.) $CO + H_2O = CO_2 + H_2$; (ii.) $2H_2 + O_2 = 2H_2O$. He now describes a number of experiments in elucidation of this question.

The power of causing combination between carbonic oxide and oxygen, by certain bodies, was the first subject of study. The action of thirteen substances was investigated. Seven of these contained hydrogen, and they were all effective; the remainder, free from hydrogen, were ineffective. The conclusion that steam acts by virtue of its own peculiar chemical properties, and not as a mere third body, thus seems quite justifiable. It is admitted by the author that he cannot prove directly that the steam is chemically changed during the explosion, but he shows that the cycle of reactions in accordance with his hypothesis can occur under the existing conditions. The reactions are (i.) the decomposition of steam by carbonic oxide and (ii.) the combination of hydrogen and oxygen. Traube, on the ground that the first reaction does not take place, rejects the hypothesis. He assumes that hydrogen peroxide is successively formed and decomposed thus (i.) $CO + H_2O + O_2 = CO_2 + H_2O_2$ and (ii.) $CO + H_2O_2 = CO_2 + H_2O$. Dixon quotes Groves, who conclusively proved (1846 and 1847) that while carbonic acid is reduced by hydrogen when the gases are heated by a loop of platinum wire, the inverse reaction also ensues, carbonic oxide and steam forming carbon dioxide and hydrogen.

Dixon then investigates the effect of a coil of platinum wire, heated to various temperatures by electricity, on mixtures of carbonic oxide and steam, as well as of carbon dioxide and hydrogen contained in a eudiometer over mercury, and he establishes the following facts: The decomposition of steam by carbonic oxide begins at a dull red heat, and the amount of decomposition, which in each case attains a maximum in a few hours and then becomes constant, increases with rise of temperature up to bright redness, when about 14 per cent. of the carbon monoxide is converted into carbon dioxide, an equivalent amount of hydrogen being liberated. The final result is the same when a mixture of equal volumes of hydrogen and carbon dioxide is heated by the coil, about 14 per cent. of carbon dioxide remaining undecomposed when the coil is heated to bright redness. But if in either case one of the products of the change—the carbon dioxide on the one hand and the water on the other—be removed, the reaction may be carried to completion.

Somewhat different is the action of induction sparks on a mixture of carbonic oxide and steam, for, with moderately powerful sparks, not only carbon dioxide, but also formic acid, are formed, while with very powerful sparks carbon is deposited. With a mixture of carbon dioxide and hydrogen, 93·6 per cent. of carbon monoxide was formed, and also traces of formic acid.

The effect of varying quantities of steam on the combustion of carbonic oxide was studied by saturating the gas at different temperatures, and it was found that the amount of decomposition increased with the quantity of steam present. It has also recently been shown by Naumann and Pistor (*Ber.*, 1885, 2894) that when carbonic oxide and steam are heated in a tube, the reaction takes place at temperatures above about 600°.

(2.) *The Action of Hydrogen on Oxygen.*—Traube observed that when a jet of burning hydrogen is made to dip into water, hydrogen peroxide is formed, and he concluded that either hydrogen and oxygen unite directly to form hydrogen peroxide, or that the following reactions occur: (i.) $H_2 + H_2O + O_2 = H_2O + H_2O_2$ and (ii.) $H_2 + H_2O_2 = 2H_2O$. Dixon confirms Traube's observation, but finds that the same effect is produced by a flame of pure cyanogen, while on the other hand the presence of steam is not necessary for the combustion of this gas. The formation of hydrogen peroxide appears to be due merely to the heating effect of the flame of carbonic oxide on cyanogen, and this conclusion is borne out by the fact that hydrogen peroxide is produced by the rapid evaporation of pure water in the absence of any flame. Again, the most careful experiments show that hydrogen and oxygen, thoroughly dried by phosphorus pentoxide, and perfectly pure, combine at a high temperature; and Berthelot and Vieille (*Compt. Rend.*, 95, 151) have shown that the rate of the explosive wave in hydrogen and oxygen is identical with the mean velocity of translation of the steam molecules formed in the reaction at the maximum temperature of the explosion, and not with the velocity of hydrogen peroxide molecules, or with a velocity intermediate between the two. Dixon has shown, lastly, that when a mixture of carbonic oxide and hydrogen in any proportion is exploded with a volume of oxygen less than half as great as that of the hydrogen, the pressure being greater than the critical pressure, and the temperature sufficiently high to prevent the condensation of steam, the following relation holds good:

$$\frac{\text{Vol. of CO} \times \text{vol. of } H_2O}{\text{Vol. of } CO_2 \times \text{vol. of H}} = 4.$$

When, however, the quantity of oxygen is greater, this ratio, termed the coefficient of affinity, is diminished. The presence of an inert gas such as nitrogen favors the formation of carbonic acid, and lowers the coefficient, and the author concludes that the excess of oxygen is inert, the oxidation of carbonic oxide only taking place by means of the steam formed. The presence of inert oxygen is, however, precluded by Traube's hypothesis, and there ought therefore to be no lowering of the coefficient. The same argument tells also against the "contact theory" of the action of steam.

On the other hand, if hydrogen and oxygen combine directly to form hydrogen peroxide, then the lowering of the coefficient should occur when the volume of oxygen is equal to that of the hydrogen.—*Harold Dixon, J. Chem. Soc.* (*Trans.*), 1886, 94-114.

THE THEORY OF THE INTERACTION OF CARBON MONOXIDE, WATER, AND OXYGEN GASES.

ARMSTRONG suggested, in his address to the Chemical Section of the British Association at Aberdeen, that the water may exercise the same kind of action on the oxygen and carbon monoxide as it (or rather the dilute sulphuric acid) does in a Groves gas battery, and that its hydrogen does not become free in any ordinary

sense. In the Groves gas battery, the system before the circuit is closed may be represented thus:

$$\begin{array}{c|c|c} O & H_2SO_4 & H_2 \\ \hline \dot{O} & H_2SO_4 & H_2 \end{array}$$

And afterward:

$$\begin{array}{c|c} OH_2 & SO_4H_2 \\ \hline OH_2 & SO_4H_2 \end{array}$$

The state before and after the explosion of a mixture of CO, O_2, and H_2O may be similarly represented thus:

$$\begin{array}{c|c|c} O & H_2O & CO \\ \hline \dot{O} & H_2O & CO \end{array} \qquad \begin{array}{c|c} OH_2 & OCO \\ \hline OH_2 & OCO \end{array}.$$

Armstrong considers it conceivable that the influence exerted by the water may be of a mechanical order; that, in fact, it exerts a mere contact action, serving to bring together the carbon monoxide and oxygen, which are straining at each other.

He also considers that Mr. Dixon's "coefficient of affinity" is explicable by either of their hypotheses, but denies that his conclusion that oxygen is inert towards carbon monoxide follows necessarily from the facts published.—A Note on Mr. H. B. Dixon's Paper on the Action of Carbonic Oxide on Steam.—*Henry E. Armstrong, J. Chem. Soc.* (*Trans.*), 1886, 112-114.

MICROSCOPY IN MEDICINE.*

A. G. FIELD, M.D., Des Moines, Iowa.

IF there is misfortune in our natural deficiencies of feeling, of hearing, and of seeing, and if the progressive and arbitrary demands of modern medicine upon the special senses impress us with a sort of disagreeable consciousness of the fact, that misfortune has been met to a large extent by the supplemental aids incidentally supplied in the rapid advancement of the physical sciences. At the bedside and in his office, the modern physician employs these aids to a large extent, and more constantly than do those engaged in any other calling or profession. This is emphatically true in relation to the microscope. In normal and pathological histology, in diagnosis and prognosis, as well as in the etiology of disease, this adjunct to the sense of seeing is indispensable.

The microscope brings nearly every branch of medical science within the pale of rationality; and it renders the present an era of demonstration rather than of theory, so that the student, as a rule, proceeds from the college to the field of practice with clear-cut opinions upon the subjects of his work.

It would appear idle on an occasion like this, and before such an audience, to attempt a review of microscopy as a factor in the establishment of our present advanced knowledge of nearly every disease. It alone has disclosed the fascinating pictures of tissue structure and tissue change in health and in growth, and of tissue change in degeneration and disease; and it has furnished everywhere suggestions to improve our therapeutics, as well as hygiene. Our text-books are our witnesses.

But accepting the germ theory of disease as the true one, we have presented a subject for microscopy far beyond the subjects of tissue structure and tissue change, in point of abstruseness and value as well, which has been but little more than fairly entered. There is here among the subtile agents of contagion and infection, an unlimited domain where the microscope must be the chief or only guide. While much of great value has already been brought to the surface, it is impossible to predict the future importance of medical microscopy with objectives of the more refractive glass recently brought out, and the improved methods of culture, isolation, and inoculation. It may be profitable, therefore, on such an occasion as this, to open for discussion some questions pertaining to manner of inquiry for facts which appear to lie beyond the boundaries of our present knowledge; for well considered and systematized preliminaries are even more essential in these undertakings than in any others. The biological nature, habitat, and habits of any given poison should be studied as far as possible from a recognition of all the general conditions or circumstances or phenomena attending its manifestations, and these formulated to be used as guides in further studies. As bearing upon the subject, I venture to offer two propositions:

First, that a disease poison, if originating or propagating within the body, is most abundant, mature, and virulent in connection with the tissues, secretions, solids, or fluids which furnish a natural pabulum, and hence in this connection it will be most susceptible of discovery.

Second, that the study of any given disease poison, as far as possible from the general conditions or circumstances attending its action, furnishes valuable suggestions for procedures, and in some measure points to the biological nature, habitat, habits, and physical attributes of such poison.

If these propositions have been well considered, it would appear to be pertinent to inquire whether the recent studies relating to the infections of *rabies* and of *cholera* have been wisely directed by what have been regarded as settled facts deduced from general observations.

In the veterinary school of Berlin, more than fifty years ago, experiments were made with reference to the poison of rabies. It was then satisfactorily demonstrated that the poison was not volatile, that its vehicle is the saliva, and pabulum the salivary glands of rabid animals, and that it does not exist in the nervous pulp, which in a putrid condition is now being employed by Pasteur and his followers for prophylactic inoculations. These experiments and observations were repeated and the facts verified by such authorities as Trolliett, Berschet, and Majendie.

Of fifty-nine dogs inoculated with saliva, fourteen became rabid. It was also established by statistics that but one person in eighteen or twenty bitten by rabid animals became infected with the disease, and it has long been known that hydrophobia, or water dread, is not constant in rabies, and that it may be concomitant in the morbid conditions including blood poison diseases. Without extending references, the above is sufficient to raise a doubt as to whether Pasteur has found or is using the poison of rabies in the putrid brain infusion with which he is operating.

But that Pasteur is operating with an infectious poison there can be no doubt, and a brief reference to one of the forms of septicæmia from inoculation with putrid meat infusion may throw some light on the subject. From an extended series of experiments Dr. Sanderson names the following symptoms as characterizing septicæmia with inoculation with putrid meat infusion: "Dullness of the eyes, with increased conjunctival secretion, finally gluing the lids together." Pasteur, it would appear, regards this as almost pathognomonic of rabies.

"At first the animal moved but little, was languid, had loss of appetite, weakness and slowness of respiration and circulation." These symptoms were succeeded by "restlessness, insane acts, muscular twitchings, spasms, and death." These are the symptoms, then, to be expected in this form of septicæmia, and they are, substantially, what Pasteur claims to produce in modified form by his inoculations. There is a strong probability, therefore, that investigations pushed however far with Pasteur's inoculation fluid will not discover the real poison of rabies nor result in prophylaxis, unless from *similarity* rather than identity of poison, which claim, so far as I know, has not been set up. There is an equally strong probability, too, that the poison does exist in greatest abundance, maturity, and virulence in the saliva and salivary glands of rabid animals, and that these are the proper or more promising subjects for investigations by inoculation, cultivation, and microscopy.

Much has been said and written for and against Koch's comma bacillus as the cause of cholera. All bacilli are vegetable in nature. They are flowerless plants, but devoid of chlorophyl; they do not subsist, as most other plants do, by the decomposition of carbonic acid gas, but take oxygen direct from the atmosphere and the pabulum in which they live. Some of them are endowed with the power of passive motion, but to none of them, so far as I know, nor to their spores, have been attributed self-propelling powers for aerial navigation. Their transportation is accomplished by accident and by atmospherical currents. I submit the question as to whether the history of cholera invasion and spread accords with such agencies.

With a sort of home upon the Ganges, in the form of an almost perpetual endemic, it occasionally becomes in some sense migratory and epidemic in nearly all parts of the world. The lines of its ravages do not correspond to the varying currents of the atmosphere nor to accidental forces. The history of these epidemics shows a movement from place to place with some regard to regular succession as to time and to constancy as to direction, and with but secondary regard to prevailing winds or to geographical obstacles. Dr. Snow detailed the movements of one epidemic of this disease with perhaps as much faithfulness as any that has been published.

Breaking out at Jessore, it proceeded to Calcutta, from where it radiated simultaneously in three distinct lines, one southwest to Madras, another southeast along the opposite coast of the Bay of Bengal, and a third northwest along the valley of the Ganges. These streams of pestilence in their several directions pursued the even tenor of their way, halting and again breaking out at irregular intervals at nearly every step, until they well-nigh enveloped the earth.

The same general facts will appear in tracing the course of some other epidemics of this disease, which any one can do at leisure.

Without taking further time, therefore, to review the general behavior of the poison during its migrations, we venture the prediction that when found to the satisfaction of all, as I believe it will be, the poison of cholera will prove to be possessed of self-propelling powers such as do not belong to any bacillus, but which harmonize with the animalcular hypothesis. And since the English Commission, headed by Dr. Klein, has failed to identify the comma bacillus as the etiological agent of cholera, as claimed by Dr. Koch, it is at least presumable that more satisfactory results may be predicted when microscopy cultivation and inoculation shall be pushed with special reference to the animalcular theory.

As to other infections, I may mention briefly that those of yellow fever, milk sickness, and typhus fever are believed to be swallowed with the food, and hence reside in the atmosphere as well as in the alimentary tract; that those of measles, scarlet fever, and whooping cough are thought to be inhaled, and hence reside in the air passages as well as in the atmosphere; and that those of small-pox, diphtheria, and erisypelas may be inoculated, and hence may be looked for in the blood.

When so much precision of manipulation and care is required as in the advanced microscopy employed in these studies, and where appearances are so liable to misrepresentation, it is fortunate that modern science has brought forth a ready means of verification in micro-photography. The rays of light are no respecters of persons nor of theories, and no delusions of sight nor intellect can pervert the faithful evidence of a photograph. Some of these I shall show by projection tonight, the subjects for the most part histological. In some instances the amplification is three thousand, and upon the canvas the images will be enlarged many more diameters.

* Read before the annual meeting of the Iowa State Medical Society, held in Des Moines, May 18-21, 1886.—*The Microscope.*

SALOL, A NEW THERAPEUTIC AGENT.

THE attention of the medical world is now attracted to a new therapeutic agent, called salol, which is at present better known in Germany, Switzerland, and France than with us. Physicians are seriously inquiring whether salol will, or will not, supersede salicylic acid and salicylate of soda in the treatment of rheumatic fever and exanthematous diseases in general.

The pharmaceutical and therapeutic properties of this new substance were brought prominently forward at a recent meeting of the Society *L'Union Medicale* of Berne, by Dr. Sahli. It forms a white powder, somewhat unctuous to the touch, having a faint aromatic odor and no taste; it is nearly insoluble in water, but soluble with ease in alchol and other solvents. According to Dr. Von Nencki's experiments on animals, when salol is given with the food it is entirely recovered in the urine in the form of uric compounds of salicylic and sulpho-carbolic acids, showing that salol is entirely decomposed in passing through the animal economy. Von Nencki also discovered that this splitting up of salol is due to the action of the pancreatic fluid. When salol is mixed with pancreatic tissue, hashed up, the decomposition referred to soon occurs. From this fact it is concluded that the splitting up of salol takes place in the duodenum, and not in the stomach, hence the absence of nausea and other gastric symptoms after its administration.

The same author has found that a dose of 4 grammes (61½ grains) per diem may be taken without inconvenience by man; and double that quantity was taken by Dr. Sahli without experiencing any buzzing in the ears. His patients have complained of this symptom occasionally, but it appears to be less prominent with salol than with salicylate of soda; and the last-named practitioner gives, he says, from 6 to 8 grammes (92 to 123 grains) of salol in the twenty-four hours.

After the administration of salol, the urine becomes very dark, almost black, as is remarked after carbolic acid has been taken. In fact, 38 per cent. of the weight of salol is made up of the elements of carbolic acid, and it is noteworthy that in spite of this large amount of copulated carbolic acid (viz., 33 to 47 grains in 92 or 123 grains of salol), it does no harm whatever, as in the form of salol it passes beyond the stomach.

Dr. Sahli has tried this new therapeutic agent in all kinds of rheumatic affections, both acute and chronic; he declares that he has obtained results quite equal to those got by salicylate of soda, and the fever seemed to be more rapidly brought down than by the latter.

A case of chronic nettle-rash, which for several months had resisted all medical treatment, yielded very promptly to salol, and the same may be said of several cases of sub-orbitary neuralgia.

The same author shows that salol is a powerful antipyretic, as he had a rapid fall of temperature in a case of pulmonary consumption. Antipyretics in such cases are, as every one knows, rather precarious; but in this instance the temperature fell from 40° C. (104° F.) to 36° C. (97° F.) after the administration of 2 grammes (31 grains) of the new medicament, and, fortunately, without any subsequent accidents. In phthisis it is, therefore, prudent to commence with small doses, say ½ gramme (8 grains).

Salol appears to be equally indicated in cases of diabetes, since both carbolic acid and salicylic acid have been prescribed in this disease. The properties already referred to would permit the administration of a larger equivalent dose of carbolic acid in the shape of salol than when given as carbolic acid itself.

Salol can be used as a local antiseptic in cases of intestinal catarrh with flatulency, and with bilious symptoms (since Lavachoff has pointed out that the bile is diluted by salicylate of soda). It can also be given in typhoid fevers to disinfect the ulcerations of the intestines, and in cholera also as a local disinfectant. Finally, it is recommended as a remedy for intestinal worms.

Besides this, salol should be tried, according to Sahli, in cases of catarrh of the bladder; for the urine of a patient treated by this new medicament remained free from putridity at a temperature of 102° F. for the space of several weeks.

Moreover, we are told that salol has been successfully used in ozena, without producing the intolerable pain caused by insufflation of salicylic acid powder into the nostrils; and the same may be said of its use in othorrhœa.

When salol is dissolved in alcohol, and a few drops of the solution mixed with water, an emulsion is obtained which it is thought might prove serviceable for injections. Dr. Sahli himself uses this emulsion for keeping the teeth in order, and free from decay.

Dr. Fuster has reported that in a case of migraine which resisted treatment with salicylic acid, immediate relief was obtained with salol. The same practitioner also used the new remedy in four cases of lumbago, with satisfactory results. On the other hand, in treating a case of polyarticular rheumatism, he found, after two days' administration of salol, that the pain in the joints remained without the slightest improvement, and that it ultimately yielded to a salicylic acid treatment.

The physician in chief of the Swiss army, Professor Ziegler, is of opinion that salol deserves attention as likely to prove of great service in the treatment of the sick and wounded on the battle-field.

THE TREATMENT OF CHRONIC HEART DISEASE.

THE observations of Dr. Schott, of Nauheim (*Berliner Klin. Wochensch.*) 1885, Nos. 33-36), since 1871, extend over 300 cases, and the clinical histories of a fair proportion of these are followed up. It will be remembered that Stokes was the first to advocate a life of active exercise in chronic heart disease. Indeed, Stokes went so far as to say that, for a man with well compensated valvular lesion, the greatest misfortune that could happen to him was to have his cardiac trouble discovered by a medical man. This was because a number of restrictions were, as a rule, imposed upon his usual mode of life, all tending to a debilitating illness. The consequence was that the heart muscle, like the other muscles of the body, lost strength, and dilatation of the heart supervened earlier than would otherwise have been the case.

Stokes' doctrine of the positive value to the heart of a life of activity has received more attention on the Continent than among his own countrymen. In Germany, especially, it has been developed into a complete system of treatment, on various lines. Oertel, as is well known, prefers hill climbing to any other method, care being taken to ward off any threatening dyspnœa by repeated stoppages, and by making a few deep voluntary respirations before proceeding. This mode of exertion is selected partly also from a desire to unload the venous system, and the right side of the heart in particular, by diminishing the volume of the blood generally; and the excessive perspiration induced by mountain expeditions does this gradually and effectually, the supply of liquid being duly restricted by removal of the excess of water from the blood.

Dr. Schott makes great use of stimulating baths, together with the systematic exercise of the various muscles of the body at home by the aid of an assistant; but the bath is made apparently the chief element of the treatment. An artificial Nauheim bath (apart from carbonic acid) may be-

rudely imitated by adding to softish water 1 to 1½ per cent. of common salt and as much per mille of chloride of calcium, the temperature being 93° F. Very weak patients have the water a little warmer, but not beyond 96° F.; and in all cases the bath should be a short one, a second chill being avoided. The baths are gradually made stronger, cooler, and the patient remains in longer, according as he improves. The full strength is from 2 to 3 per cent. of chloride of sodium and from ½ to 1 per cent. of chloride of calcium, with carbonic acid. The last named may be supplied artificially by adding equal parts by weight of bicarbonate of soda and hydrochloric acid, the full strength being 1 kilogramme of each in a bath of 250 liters. But much smaller quantities suffice at first.

The exercises consist of various movements of the limbs and trunk, each movement being opposed by an assistant, who gives way as the patient exerts his strength. The greatest care is taken that the patient breathes easily the whole time. The details may be found in Dr. Schott's original article (*Berlin Klin. Wochensch.*, Nos. 33–36, 1885), reprinted as a pamphlet by Schumacher, of Berlin.

The therapeutic results have already been summarized in these columns. Suffice it to say that diminution of the cardiac dullness during a course of baths can be actually demonstrated, and, as a rule, the improvement in the patient's condition is immediate and striking.

No alteration is made in the solid food, but Dr. Schott has for years restricted the fluid supply whenever high arterial pressure existed. Finally, mountain tours are recommended where there is obesity, but in moderation.

This system of baths and exercise is a rival to Oertel's mountaineering system, and possesses advantages, in that it can be used at home, and can be regulated to a nicety to suit the patient. But Dr. Schott's observations lack the scientific precision of Prof. Oertel's. It is earnestly to be hoped that a more active life may be ordered by medical men generally in the treatment of heart disease. It is to be feared that a merely passive existence is still widely recommended to any unfortunate patients with (mitral) valvular lesion and dyspnœa.

[Nature.]

THE LUNAR SURFACE AND ITS TEMPERATURE.

A MONOGRAPH by the writer, relating to the temperature of the lunar surface, read before the American Academy of Science, September, 1869, contained the following: "Are we not forced to dissent from Sir John Herschel's opinion that the heat of the moon's surface, when presented to the sun, much exceeds that of boiling water? Raised to such a high temperature, our satellite, with its feeble attraction, could not possibly be without an envelope of gases of some kind. Indeed, nothing but the assumption of extreme cold offers a satisfactory explanation of the absence of any gaseous envelope round a planetary body which, on account of its near proximity, cannot vary very much from the earth as regards its composition. The supposition that this neighboring body is devoid of water, dried up, and sunburnt will assuredly prove one of the greatest mistakes ever committed by physicists." This assertion was based on demonstrations showing that the circular walls of the great "ring mountains" on the lunar surface are not, as supposed, composed of "mineral substances originally in a state of fusion." The height and diameter of these walls being recorded in "Der Mond," computations based on the safe assumption that the areas of their transverse sections cannot be less than the square of their height, establishes the important fact that the contents of the wall of, for instance, Tycho, the circumference of which is 160 miles, height 2·94 miles, amounts to $2·94^2 \times 160 = 1,382$ cubic miles. The supposed transfer of this enormous mass, in a molten state, a distance of 25 miles from the central vent imagined by Nasmyth, and its exact circular distribution at the stated distance, besides its elevation to a vertical height of nearly 3 miles, involve, I need not point out, numerous physical impossibilities. Other materials and agencies than those supposed to have produced the "ring mountains" must consequently be sought in explanation of their formation. A rigid application of physical and mechanical principles to the solution of the problem proves conclusively that water subjected successively to the action of heat and cold has produced the circular walls of Tycho. The supposition that these stupendous mounds consist of volcanic materials must accordingly be rejected, and the assumption admitted that they are inert glaciers which have become as permanent as granite mountains by the action of perpetual intense cold.

Independently of the foregoing demonstration, the fallacy of the volcanic hypothesis will be comprehended by its advocates on learning that the quantity of lava requisite to form the circular walls of Tycho would cover the entire surface of England and Wales to a depth of 125 feet.*

Before proceeding further with our demonstration, it will be necessary to establish the maximum temperature which solar radiation is capable of imparting to the lunar surface. This temperature, of course, varies with the distance of the primary and its satellite from the sun. By means of an actinometer, the bulb of whose thermometer receives an equal amount of radiant heat on opposite sides, I was enabled to determine with desirable accuracy, sixteen years ago, that, when the earth is in aphelion, solar radiation on the ecliptic imparts a maximum temperature of 67·2° F., and that the retardation of the radiant energy occasioned by the want of perfect atmospheric diathermancy reaches 0·207. Consequently, the temperature produced by solar radiation at the boundary of the terrestrial atmosphere is

$$67·2 \times 1·207 = 81·11° \text{ F.}$$

when the earth is in aphelion. Agreeably to observations during the winter solstice, compared with observations at midsummer, at equal zenith distance, the augmentation of solar intensity when the earth is in perihelion amounts to 5·84° F.; hence the temperature produced by solar radiation reaches

$$81·11 + 5·84 = 86·95° \text{ F.}$$

* Area of England and Wales, 58,320 square miles; contents of the walls of Tycho, 1,382 cubic miles; hence, $\frac{1,382}{58,320} \times 5,280 = 125·12$ feet.

when the rays enter our atmosphere during the winter solstice. It should be observed that on theoretical grounds the increase of temperature, when the earth is in perihelion, will be in the inverse ratio of the *dispersion of the solar rays*; hence, as the aphelion distance is to the perihelion distance as 218·1 to 210·9, it will be seen that the temperature produced by solar radiation when the earth is in perihelion will be

$$\frac{218·1^2 \times 67·2°}{210·9^2} = 71·86° \text{ F.}$$

Adding 0·207 for retardation caused by imperfect atmospheric diathermancy, solar intensity during the winter solstice will be

$$71·86 \times 1·207 = 86·73° \text{ F.}$$

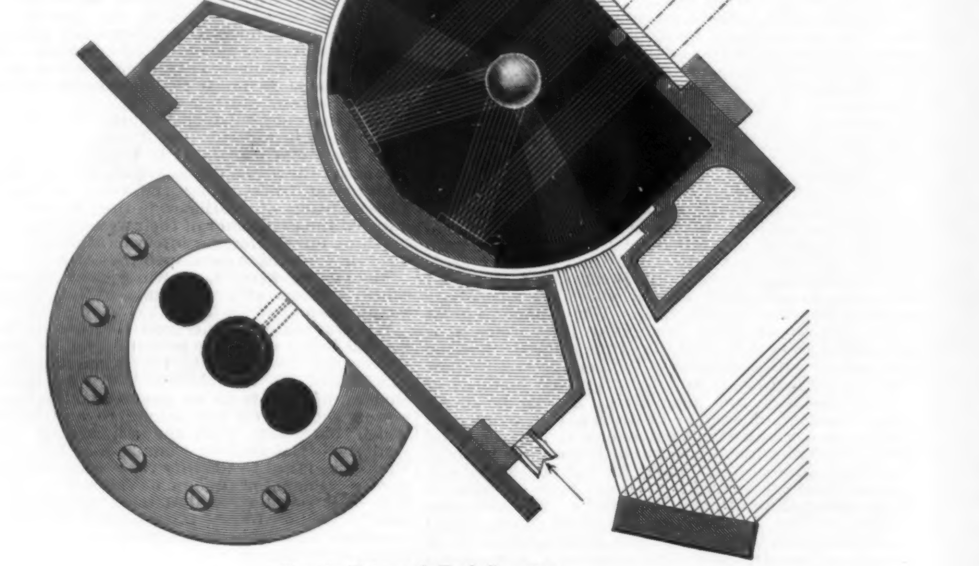
Calculation based on *observation*, as before stated, proves that the perihelion temperature is 86·95°, thus showing a trifling discrepancy between theory and observation.

Adopting 86·73° as correct, it will be found that the yearly *mean* temperature produced by solar radiation when the rays enter the earth's atmosphere will be

$$\frac{81·11° + 86·73°}{2} = 83·92° \text{ F.},$$

while the temperature produced by the sun's radiant heat is only 81·11° during the summer solstice, as before shown. Hence the temperature of the lunar surface when presented to the sun while the earth is furthest from the luminary can only be augmented 81·11° F.

The remarkable fact that the moderate heat produced by solar radiation is capable of increasing the temperature of bodies previously heated to a high degree, demands consideration in connection with the subject under investigation; also the nature of the device, before referred to, for ascertaining the temperature produced by solar radiation. The accompanying illustration represents a combination of said device and a pyrheliometer differing materially from Pouillet's instrument, by showing the true intensity of the "fire" in the sun's rays.



Captain Ericsson's Pyrheliometer.

The illustration presents a top view and a vertical section of the new instrument through the center line. The upper part, composed of bronze, is cylindrical with a flat top, the bottom being semispherical, composed of ordinary glass. The top of the cylindrical chamber is provided with three circular perforations covered by a thin crystal carefully ground and polished. A thermometer having a spherical bulb is introduced through the side of the chamber, the bulb being central to the transparent semispherical bottom. A short parabolic reflector, shown in section on the illustration, surrounds the instrument, adjusted so that its focus coincides with the center of the bulb of the thermometer. The compound cylindrical and spherical chamber is inclosed in a vessel containing water, appropriate openings at top and bottom being provided for maintaining constant circulation during experiments. Efficient means are also provided for exhausting the air from the internal chamber. The instrument is secured to the top of a substantial table, which, during experiments, faces the sun at right angles by the intervention of a parallactic mechanism. Movable shades are applied, by means of which the sun's rays may be quickly cut off from, or admitted to, the parabolic reflector; while other shades enable the operator to admit or exclude the solar rays from the circular perforations at the top of the exhausted chamber. It will be readily understood that the parallel lines within the exhausted chamber, shown on the illustration, indicate the course of the solar rays passing through the crystal and the perforations at the top, while the converging radial lines indicate the rays reflected by the parabolic reflector. The upper hemisphere of the thermometric bulb, it will be seen, receives the radiant energy of the sun's rays which pass through the large central perforation; while the lower half of the bulb will be acted upon by the rays passing through the small perforations. These rays are reflected upward by two inclined circular mirrors attached to the bottom of the exhausted chamber. It should be particularly observed that the areas of these inclined mirrors *together* should exceed the area of the great circle of the bulb of the thermometer sufficiently to make good the loss of radiant energy caused by the imperfect reflection of the said mirrors, and also to make good the loss attending the passage of the solar rays through the crystal.

A capacious water cistern, connected by flexible tubes with the external casing of the pyrheliometer, enables the operator to maintain the exhausted chamber at any desirable temperature. Engineers of great experience in the application of heat for the production of motive power and other purposes deny that the temperature of a body can be increased by the application of heat of a lower degree than that of the body whose temperature we desire to augment. The soundness of their reasoning is apparently incontrovertible, yet the temperature of the mercury in the instrument just described, raised to 600° F. by means of the parabolic reflector, increases at once when solar heat is admitted through the circular apertures, although the sun's radiant intensity at the time may not reach one-tenth of the stated temperature. It should be mentioned that the trial of this new pyrheliometer has not been concluded, owing to very unfavorable atmospheric conditions since its completion. For our present purposes, the great fact established by the illustrated instrument is sufficient, namely, that the previous temperature of a body exposed to the sun's radiant heat is immaterial. The augmentation of temperature resulting from exposure to the sun, the pyrheliometer shows, depends upon the intensity of the sun's rays.

Regarding the temperature prevailing during the lunar night, its exact degree is not of vital importance in establishing the glacial hypothesis, since the periodical increment of temperature produced by solar radiation is only a fraction of the permanent loss attending the continuous radiation against space resulting from the absence of a lunar atmosphere; besides, all physicists admit that it is extremely low. Sir John Herschel says of the night temperature of the moon that it is "the keenest severity of frost, far exceeding that of our polar winters." Proctor says: "A cold far exceeding the intensest ever produced in terrestrial experiments must exist over the whole of the unilluminated hemisphere."

The author of "Outlines of Astronomy" has also shown that the temperature of space, against which the moon at all times radiates, is —151° C. (—239·8° F.), Pouillet's estimate being —142° C. (—223·6° F.). Adopting the latter degree, and allowing 81·11° for the sun's radiant heat, we establish the fact that the temperature of the lunar surface presented to the sun will be 223·6° less 81·1°, or —142·5° F., when the earth is in aphelion.

It will be well to bear in mind that when the earth is in the said position, the sun's rays acting on the moon subtend an angle of 31′ 32″, hence the loss of heat by radiation against space will be diminished only 0·000021 during sunshine. Nor should Herschel's investigation be lost sight of, showing that stellar heat bears the same proportion to solar heat as stellar light to solar light. Stellar heat being thus practically inappreciable, the temperature produced by stellar radiation cannot be far from absolute zero—an assumption in harmony with the views of those who have studied the subject of stellar radiation, and consequently regard Pouillet's and Herschel's estimate of the temperature of space as being much too high.

Having disposed of the question of temperature, let us return to the practical consideration of the glacial hypothesis. The formation of annular glaciers by the joint agency of water and the internal heat of a planetary body devoid of an atmosphere and subjected to extreme cold is readily explained on physical principles. Suppose a sheet of water, or pond, on the moon's surface, covering the same area as the plateau of Tycho, viz., 50 miles diameter and 1,960 square miles. Suppose, also, that the internal heat of the moon is capable of maintaining a moderate steam pressure, say 2 lb. to the

square inch, at the surface of the water in the pond. The attraction of the lunar mass being only one-sixth of terrestrial attraction, while the moon's surface is freed from any atmospheric pressure, it will be evident that under the foregoing conditions a very powerful ebullition and rapid evaporation will take place, and that a dense column of vapor will rise to a considerable height above the boiling water.

It will also be evident that the expansive force within this column at the surface of the water will be so powerful at the stated pressure that the vapor will be forced beyond the confines of the pond in all directions with great velocity. No vertical current, it should be understood, will be produced, since the altitude of the column, after having adjusted itself to the pressure corresponding with the surface temperature of the water, remains stationary, excepting the movement consequent on condensation from above.

The particles of vapor forced beyond the confines of the pond, on being exposed to the surrounding cold, caused by unobstructed radiation against space, will of course crystallize rapidly, and in the form of snow fall in equal quantity round the pond, and thereby build up an annular glacier. As the radius of the vaporous column exceeds 25 miles, it will be perceived that, notwithstanding the rapid outward movement, before referred to, some of the snow formed by the vapors rising from the boiling pond will fall into the same, to be melted and re-evaporated.

In connection with the foregoing explanation of the formation of annular glaciers, their exact circular form demands special consideration. An examination of Rutherford's large photograph of the lunar surface shows that, apart from the circular form of the walls, the bottoms of the depressions are in numerous cases smooth, rising slightly toward the center uniformly all round. The precision observable proves clearly the action of formative power of great magnitude. Referring to what has already been explained regarding the vaporous column of 25 miles radius, calculation shows that a surface temperature exerting the moderate pressure of 2 lb. to the square inch will produce an amount of mechanical energy almost incalculable. Practical engineers are aware that the steam rising from a surface of water 10 square feet, heated by a very slow fire, is capable of producing an energy of 1 horse power; consequently, a single square mile of the boiling pond will develop 2,780,000 horse power. This prodigious energy will obviously be exerted *horizontally*, as the weight of the superincumbent column of vapor balances its *expansive* force, precisely as the weight of our atmosphere balances its expansive force. But, unlike the earth's atmosphere, which is restrained from horizontal movement by its continuance round the globe, the vapor of the column of 50 miles diameter is free to move beyond the confines of the pond. A very powerful horizontal motion, especially of the lower part of the vaporous mass, will thus be promoted, acting in radial lines from the center, the principal resistance encountered being the friction against the water. Considering that the friction against the surface of the ocean, caused by the gentle trade wind, is sufficient to produce the Gulf Stream, we need no figures to show the effect on the water in the boiling pond produced by the vaporous mass propelled by an energy of 2 lb. to the square inch in radial lines toward its confines. A circular tidal wave of extraordinary power, together with a return undercurrent toward the center, will obviously be the result. But agreeably to the laws supposed to govern vortex motion, these currents cannot be maintained in a radial direction. A rotary motion, rapidly augmenting, will take place, producing a vortex more powerful than any imagined by Descartes. The radial currents of the vaporous column, having assumed a spiral course, will rapidly acquire a velocity exceeding that of a cyclone. The practical effect of the powerful movement of the vortex, it is reasonable to suppose, will resemble that of a gigantic carving tool, whose thorough efficiency in removing irregularities has been proved by the exact circular outline presented by thousands of lunar formations. The terraces within the "ring mountains" indicated on Beer and Madler's chart, it may be shown, were produced by evaporation resulting from low temperature and reduced energy after the formation of the main glacier.

There is another feature in the lunar landscape scarcely less remarkable than its circular walls and depressions. In the center of nearly all of the latter, one or more conical hills rise, in some cases several thousand feet high. Has the rotary motion of the boiling vortex any connection with these central cones? A brief explanation will show that the connection is quite intimate. The underrated estimate that 10 square feet of surface under the action of slow fire is capable of developing one horse power proves the presence of a dynamic energy exceeding 5,000,000,000 of horse power at the base of the vaporous column resting on the boiling water of a pond as large as that of Tycho. No part of this power can be exerted vertically, as already explained, on the ground that the weight of the vapor restrains such movement. The great velocity of the vortex resulting from the expenditure of the stated amount of dynamic energy will of course produce corresponding centrifugal force; hence a maelstrom will be formed, capable of draining the central part of the pond, leaving the same dry, unless the water be very deep, in which case the appearance of a dry bottom will be postponed until a certain quantity of water has been transferred to the glacier. It should be observed that the central part of the bottom, freed from water, will also be freed from the surrounding cold by the protection afforded by the vaporous mass. The quantity of snow formed above the center, at great altitude, will be small, and of course diverged during the fall. Evidently the dry central part, prevented, as shown, from cooling, will soon acquire a high temperature, admitting the formation of a vent for the expulsion of lava, called for as the moon, whose entire dry surface is radiating against space, shrinks rapidly under the forced refrigeration attending glacier formation. Lava cones similar to those of terrestrial volcanoes, and central to the circular walls, may thus be formed, the process being favored by the feebleness of the moon's attraction. The existence of warm springs on the protected central plains is very probable; hence the formation of cones of ice might take place during the last stages of glacier formation, when those plains no longer receive adequate protection against cold.

In accordance with the views expressed in the monograph read before the American Academy of Science, continued research has confirmed my supposition that the water on the moon bears the same proportion to its mass as the water of the oceans to the terrestrial mass. I have consequently calculated the contents of the circular walls of the "ring mountains" measured and delineated by Beer and Madler, and find that these walls contain 680,000 cubic miles. The opposite hemisphere of the moon being subjected to similar vicissitudes of heat and cold as the one presented to the earth, the contents of the circular walls not seen cannot vary very much from those recorded in "Der Mond"; hence the total will amount to 1,260,000 cubic miles. Allowing for the difference of specific gravity of ice, the stated amount represents 1,159,000 cubic miles of water. But "Der Mond" does not record any of the minor circular walls which, as shown by the large photograph before referred to, cover the entire surface of some parts of the moon. On careful comparison, it will be found that the contents of the omitted circular formations is so great that an addition of 50 per cent. to the before-stated amount is called for. An addition of 25 per cent. for the ice fields, whose extent is indicated by cracks and optical phenomena, is likewise proper. The sum total of water on the moon, therefore, amounts to 2,028,600 cubic miles.

Adopting Herschel's estimate of the moon's comparative mass, viz., 0·011364, and assuming that the oceans of the earth cover 130,000,000 square miles, it will be seen that the estimated quantity of water on the moon corresponds with a mean depth of 7,250 feet of the terrestrial oceans.* This depth agrees very nearly with the oceanic mean depth established by the soundings for the original Atlantic cable, viz., 7,500 feet; but the result of the Challenger expedition points to a much greater depth. This circumstance is by no means conclusive against the supposition that the satellite and the primary are covered with water in relatively equal quantities. The correctness of Sir John Herschel's demonstration proving the original tendency of the water on the lunar surface to flow to the hemisphere farthest from the earth must be disproved before we reject the assumption that the quantity of water on the surface of the moon bears the same proportion to its mass as the quantity of water on the earth to the terrestrial mass.

JOHN ERICSSON.

* $\frac{2028600 \times 5280}{130000000 \times 0·011364}$ = 7,250 feet, mean depth of terrestrial oceans corresponding with water on the moon.

JORDAN'S SOLAR REGISTERING APPARATUS.

IN the Jordan solar registering apparatus, represented herewith, the results are obtained by means of photography. The instrument consists of a cylindrical

THE JORDAN SOLAR REGISTERING APPARATUS.

camera obscura, closed by a cover. This camera is provided with two apertures, situated on each side of the axis at different heights, and through which the sunlight enters. A sensitized paper is introduced into the cylinder so as to exactly fill it. This paper contains two apertures that correspond to those in the cylinder, and is divided into spaces by vertical lines that represent the hours of the day and their fractions.

The apparatus is so placed that its axis shall be in the meridian plane of the place, and is inclined toward the horizon to the angle required by the altitude of the place of observation. This regulation is very simply effected by oscillating the camera upon a pivot, the reading being made upon a graduated arc. The rays, before the sun passes to the meridian, enter through the east aperture, and, after it has passed thereto, through the west aperture, and traveling, by reason of the earth's rotary motion, leave upon the sensitized paper the distinct trace of a chemical action, which consequently registers their duration and degree of intensity. These traces are rendered permanent by a simple washing with water. The apparatus registers uninterruptedly.—*La Nature.*

DISTINGUISHING RAYS OF SOLAR FROM THOSE OF TERRESTRIAL ORIGIN.

By Professor CORNU.

IT has been shown by M. Fizeau that, owing to the rotation of the sun upon its axis, there is a displacement of the spectral lines produced by solar absorption toward the red or toward the violet, according as to whether the light examined emanates from those parts of the sun which are receding from or approaching us. If, however, the lines are the result of absorption by the earth's atmosphere, no such displacement should occur. It has been the aim of the author to make this principle the basis of a simple and instantaneous method of determining the origin of any given line. The displacement is very minute, amounting to about $\frac{1}{15}$ of the distance between the D lines for rays in that part of the spectrum when the light is from the extremity of the solar equator, but it has been found quite sufficient. Observations have been made with a Rowland grating, the mean distance of the lines being 0·00176 mm. An image of the sun is formed upon the slit of the spectroscope by a lens. By a slight oscillatory motion given to the lens by a lever from the hand, any part of the sun's image can be brought upon the slit. A heliostat sends the rays always in the same direction, and by a prism the image has its equator horizontal. To distinguish between a line of solar and one of terrestrial origin, the line is brought near the vertical wire of the eye-piece, or, better still, one of those inevitable grains of dust which are always seen on the horizontal wire. The lever connected to the lens is then oscillated so as to bring alternately the two ends of the solar equator tangentially upon the slit. If the ray is of terrestrial origin, it remains absolutely fixed; if it is solar, it oscillates with the lever.

A NEW SAVONAROLA.

THE European papers speak at great length of the wonderful effect produced at Pisa by the sermons of Fra Agostino da Montefeltro, which have, says the London *Tablet*, attracted attention far beyond the boundaries of the preacher's own country. Fra Agostino, it is said, is one of those voices to which it is impossible to close one's ears. His is a lofty spirit, a burning enthusiasm; he rises to the highest summits of human science and religious enthusiasm; then descends into the depths of the simple human soul and the transparency of innocence. He speaks in turn to the intellect and to the sentiments; he has the true gift of tongues.

While the multitude follow him without effort, the most intelligent are equally under the charm of his words. Endowed with an astonishing rapidity of eloquence, he appears to enunciate his ideas under different forms, so as to continually captivate the aristocracy and democracy among his audience. The cathedral can hardly contain the crowds that flock to hear him preach. His auditors include radicals, unbelievers, the dreamer, the "satanic poet," as well as the poor and faithful. During his course of Lenten sermons at Pisa, this year, the train brought hearers from Florence, Leghorn, and Lucca, and crowds waited for hours at the church doors to secure places. Two hours before the sermon all the chairs were occupied. Business was at a standstill, lawyers left their offices and the courts, professors and students deserted the university; the business of the hour was to hear Fra Agostino.

The people quit their stores and workshops, and the marvelous piazza, where the Duomo, the Campanile, the Battistero, and the Camposento ordinarily raise their sculptured splendor of marble in solitary silence, is filled with noise. Thousands of heads are crowded together in the pale light beneath the painted and gilded vaults, whence still hangs the great bronze statue that taught Galileo the secret of the rotation of the earth. Fra Agostino has a keen feeling for the sufferings of the people. He preaches aloud the duties of the rich and the powerful, derived from the Evangelical law, "Love thy neighbor." He sometimes so carries away his audience that the crowds are unable to restrain themselves. Frantic and repeated applause bursts out, which he strives in vain to repress. As soon as he has pronounced his last words he suddenly disappears, makes his way to a side door, and hastens to hide himself at his residence. Unfortunately, he is by no means strong. His chest suffers, and he sometimes spits blood.

The life of Fra Agostino seems to have been of the most romantic kind. Of well-to-do family (according to the *Figaro*), he was destined for the priesthood, but in 1859, before taking holy orders, he, like so many of his contemporaries, threw aside the cassock for the red shirt, and became a Garibaldian soldier, winning his medal and his captain's epaulets by his bravery in the war of independence. He married, but very soon death carried off both wife and child, and the Garibaldian soldier sought peace in the cloister, and was soon transformed into an apostle of the Word. Many other reports and rumors are current about him, some of a less flattering kind. When questioned about his life, his own sole answer is: "Sir, I have been a great sinner."—*The Catholic Review.*

THE HEAT.

IT is not really very hot, though we feel it to be so. The truth is that although the natives of, and habitual residents in, this variable climate of ours ought to be especially responsive to changes of external temperature, and to possess the faculty of quickly adapting themselves to its requirements, we do not, as a rule, enjoy this excellent property of the organism in any remarkable degree. The special disability under which we labor relates to radiation. We are unable to get rid of heat from the skin by simple dispersion. The black man excels us in this respect. His dark skin glows, as it were, with the heat it throws off. A white man, and an Englishman particularly, resorts to the somewhat clumsy physical expedient of cooling himself by evaporation. He perspires heavily, and as the vapor leaves his body its temperature is reduced, or at least kept from rising.

The black-skinned man is less dependent on perspiration, and can cover his body with oil, so that cutaneous exhalation is actually impeded, without suffering, simply because the color of his surface is one which, like the willow pattern plate in the familiar experiment, gives off heat. Again and again the fact we are stating has been questioned; but recently, as scientists are aware, it has been demonstrated. One reason why English people are so ill prepared to endure either extreme of temperature, although they are accustomed to great and rapid changes, is to be found in the fact that they rely on clothes for heat conservation to an extent and with a constancy in excess of the habit of almost any other people.

We "wrap up" and we throw off our clothing more artificially than other folks. The way to develop a faculty of bearing extremes of temperature is to habituate the body to make its own temperature. Those who do not clothe themselves heavily in winter seldom find it necessary to make great changes in their clothing in order to bear the heat of summer.—*Lancet.*

UNBANDAGING OF THE MUMMY OF RAMESES II., AND DISCOVERY OF THE MUMMY OF RAMESES III.

PROFESSOR MASPERO'S OFFICIAL REPORT.

THE following is a verbatim translation of Professor Maspero's last official report as Director-General of the Excavations and Antiquities of Egypt, dated June 3, his resignation having been tendered on June 5:

BOULAK, June 3, 1886.

The year 1886, the 1st day of June, corresponding with the 28th day of Sha'bân, in the year 1303 of the Hegira, at 9 o'clock in the morning,

By order of, and in the presence of, His Highness Mohammed Pasha Tewfik, Khedive of Egypt, and in the presence of their Excellencies Mukhtar Pasha Ghazi, High Commissioner of His Highness the Sultan; Sir Henry Drummond Wolff, High Commissioner of Her Britannic Majesty; Nubar Pasha, President of the Council of Ministers; Abdel Kader Pasha Hilmy, Minister of the Interior; Mustapha Pasha Fehmy, Minister of Finance; Abderrahman Pasha Rouchdy, Minister of Public Works and Public Instruction; De Hitroovo, Agent and Consul-General of Russia; Khairi Pasha, Director of the Maich of His Highness the Khedive; Zulfikar Pasha, Grand Master of the Ceremonies to His Highness the Khedive; Salem Pasha, Physician to His Highness the Khedive; Abdallah Bey Fauzy and Ahmed Bey Hamdy, Aides-de-Camp to His Highness the Khedive; Chouky Bey, Daninos Bey, Takla Bey, Walpole, and Abaza.

UNROLLING OF THE MUMMY OF SESOSTRIS (RAMESES II.) BY M. MASPERO, IN PRESENCE OF THE KHEDIVE.

MM. Gaston Maspero, Director-General of the Excavations and Antiquities of Egypt, Emil Brugsch Bey, keeper, and Urbin Bouriant, assistant keeper, of the Museum of Boulak, proceeded, in the hall called "The Hall of Royal Mummies," to unbandage those two mummies which, in the printed catalogue, are numbered 5,229 and 5,233, both being among those discovered in the subterraneous hiding place at Dayr-el-Bahari.

The mummy (No. 5,233) first taken out from its glass case is that of Rameses II., Sesostris, as testified by the official entries bearing date the 6th and 16th years of the reign of the High Priest Her-hor Se-Amen and the High Priest Pinotem I., written in black ink upon the lid of the wooden mummy case, and the further entry of the 16th year of the High Priest Pinotem I., written upon the outer winding sheet of the mummy over the region of the breast. The presence of this last inscription having been verified by His Highness the Khedive, and by the illustrious personages there assembled, the first wrapping was removed, and there were successfully discovered a band of stuff (*sic*) 20 centimeters in width rolled round the body; then a second winding sheet sewn up and kept in place by narrow bands placed at some distance apart; then two thicknesses of small bandages; and then a piece of fine linen reaching from the head to the feet. A figure representing the Goddess Nut, one meter in length, is drawn upon this piece of linen, in red and white, as prescribed by the ritual. The profile of the goddess is unmistakably designed after the pure and delicate profile of Seti I., as he is known to us in the bass-relief sculptures of Thebes and Abydos. Under this amulet there was found another bandage; then a layer of pieces of linen folded in squares and spotted with the bituminous matter used by the embalmers. This last covering removed, Rameses II. appeared. The head is long, and small in proportion to the body. The top of the skull is quite bare. On the temples there are a few sparse hairs, but at the poll the hair is quite thick, forming smooth, straight locks about five centimeters in length. White at the time of death, they have been dyed a light yellow by the spices used in embalment. The forehead is low and narrow; the brow-ridge prominent; the eyebrows are thick and white; the eyes are small and close together; the nose is long, thin, hooked like the noses of the Bourbons, and slightly crushed at the tip by the pressure of the bandages. The temples are sunken; the cheekbones very prominent; the ears round, standing far out from the head, and pierced like those of a woman for the wearing of earrings. The jawbone is massive and strong; the chin very prominent; the mouth small but thick lipped, and full of some kind of black paste. This paste being partly cut away with the scissors, disclosed some much worn and very brittle teeth, which, moreover, are white and well preserved. The mustache and beard are thin. They seem to have been kept shaven during life, but were probably allowed to grow during the king's last illness, or they may have grown after death. The hairs are white, like those of the head and eyebrows, but are harsh and bristly, and from two to three millimeters in length. The skin is of earthy brown splotched with black. Finally, it may be said the face of the mummy gives a fair idea of the face of the living King. The expression is unintellectual, perhaps slightly animal; but even under the somewhat grotesque disguise of mummification, there is plainly to be seen an air of sovereign majesty, of resolve, and of pride. The rest of the body is as well preserved as the head; but in consequence of the reduction of the tissues, its external aspect is less life-like. The neck is no thicker than the vertebral column. The chest is broad; the shoulders are square; the arms are crossed upon the breast; the hands are small and dyed with henna; and the wound in the left side through which the embalmers extracted the viscera is large and open. The legs and thighs are fleshless; the feet are long, slender, somewhat flat-soled, and dyed, like the hands, with henna. The corpse is that of an old man, but of a vigorous and robust old man. We know, indeed, that Rameses II. reigned for 67 years, and that he must have been nearly 100 years old when he died.

The unbandaging of the mummy of Rameses II. took less than one-quarter of an hour. After a short pause of a few moments, at precisely ten minutes before ten o'clock, the mummy numbered 5,229 was, in its turn, removed from its glass case. It was discovered in the great sarcophagus numbered 5,247, which also contained another mummy in a very dirty and tattered condition. As this sarcophagus bore the name of Nofretari, the wife of King Ahmes I. of the XVIII. Dynasty, it had been taken for granted that No. 5,229 was the mummy of this queen. The other mummy was supposed to be that of some unknown princess who had been laid beside Nofretari by the priests employed to conceal the royal mummies in the hiding-place at Dayr-el-Bahari. Consigned to the museum stores, the mummy decayed, and gave out so foul an odor that it became necessary to get rid of it. It was accordingly opened, and proved to have been bandaged very carefully; but the body was no sooner exposed to the outer air than it fell literally into a state of putrefaction, dissolving into black matter, which gave out an insupportable smell. It was, however, ascertained to be the corpse of a woman of mature age and middle height, belonging to the white races of mankind. There were no traces of writing on the bandages, but a small strip of linen discovered in the sarcophagus No. 5,247 was decorated with a scene of adoration of King Rameses III., in the likeness of two forms of Amen. A short legend, written partly in cursive hieroglyphs and partly in hieratic, states that the piece of linen thus decorated was the gift of the head laundress of the royal household, and it was accordingly supposed that the anonymous mummy was one of the many sisters, wives, or daughters of Rameses III.

The mummy No. 5,229 was very neatly wrapped in orange-colored linen, kept in place by small strips of ordinary linen. There was no outer inscription, but upon the head was a linen band, covered with mystical figures.

M. Maspero here reminded His Highness the Khedive that Nofretari is represented upon certain monuments as of a black complexion, while upon other monuments she is seen with a yellow skin, and with the soft hair of an Egyptian woman. Hence there have arisen innumerable discussions among Egyptologists, some affirming that the queen was a negress, while others maintain that the black tint of her face and body was a fiction originating with the priests. The worship of this queen was extremely popular at Thebes, where she was deified under one of the forms of Hathor, the black goddess, the goddess of death and of the shades. The opening of the mummy No. 5,229 would, therefore, probably settle this historical question for good and all.

The orange-colored winding-sheet being removed, there appeared beneath it a white sheet bearing an inscription in four lines: "The year XIII., the second month of Shomou, the 28th day, the First Prophet of Amen, King of the Gods, Pinotem, son of the First Prophet of Amen, Piankhi, the Scribe of the temple Zoserou-Khonsu, and the Scribe of the Necropolis Boutchamou, proceeded to restore the defunct King Ra-user-ma Mer-Amen, and to establish him for Eternity."

The mummy, which had hitherto been taken for Nofretari, was then the mummy of Rameses III.; and the anonymous mummy was without doubt that of Nofretari.

This point being verified, Rameses III. was placed erect, and photographed in his bandages. Short as was the delay, it seemed too long for the impatient spectators. The strange revelation, which had substituted one of the great conquerors of Egyptian history for the most venerated Queen of the XVIII. Dynasty, had astonished and excited them to the uttermost. The unbandaging of the mummy then recommenced in the midst of general impatience.

All had left their places, and crowded round the operators. Three thicknesses of bandages were rapidly unwound; then came a casing of sewn canvas, covered with a thin coat of cement. This casing being cut with the scissors, more layers of linen appeared. The mummy seemed to diminish and reveal its forms under our fingers. Some of the wrappings were inscribed with legends and groups in black ink, notably the God Amen enthroned, with a line of hieroglyphs below, stating that this bandage was made and offered by a devotee of the period, or, perhaps, by a princess of the blood royal: "The Lady Songstress of Amen Ra, King of the Gods, Taït-aat-Maut, daughter of the First Prophet of Amen, Piankhi, in order that the God Amen should accord her life, health, and strength."

Two pectoral ornaments were laid in the folds of the wrappers, one of gilt wood, bearing the usual group of Isis and Nepthys adoring the sun; the other in pure gold, inscribed with the name of Rameses III. One last wrapper of stiffened canvas, one last winding sheet of red linen, and then a great disappointment, keenly felt by the operators; the face of the king was covered with a compact mass of bitumen, which completely hid the features. At 20 minutes past 11 His Highness, the Khedive, left the Hall of Mummies.

The work was resumed in the afternoon of the same day, and on Thursday morning, the 3d of June, a fresh examination of the bandages revealed inscriptions upon two of them. The first is dated the year IX., the second the year X., of the High Priest Pinotem I. The tarry substance upon the face of the mummy being carefully attacked with the scissors, was detached little by little, and the features became visible. They are less well preserved than those of Rameses II., yet they can to a certain extent be identified with those of the portraits of the conqueror. The head and face are closely shaved, and show no trace of hair or beard. The forehead, without being very lofty or very broad, is better proportioned and more intellectual than that of Rameses II. The brow-ridge is less prominent, the cheekbones are less high, the nose is less hooked, the chin and jaw are less heavy. The eyes appear to be larger, but it is not possible to be certain of this last point, the eyelids having been removed, and the cavities of the eyeballs having been stuffed with rags. The ears are closer to the head than those of Rameses II., and they are pierced in like manner for the reception of earrings. The mouth is disproportionately wide, and the thin lips reveal a row of white and well-placed teeth. The first molar on the right side appears to have been broken, or to have been worn away earlier than the rest. In short, Rameses III. is like a smaller imitation of Rameses II. The physiognomy is more delicate, and, above all, more intelligent; but the height of the body is less, the shoulders are less wide, and the strength of the man was inferior. What he was himself in his individual person as compared with Rameses II., so was his reign as compared with the reign of Rameses II. His wars were not fought in Syria or Ethiopia, but at the mouths of the Nile and on the frontiers of Egypt. His buildings were of a poor style and of hasty construction. His piety was as pompous as that of Rameses II., but his resources were more meager. His vanity was, however, as boundless; and such was his supreme desire to copy in all things the exaple of his illustrious predecessor, that he gave to his sons the names of the sons of Rameses II., and almost in the same order of birth.

The two mummies, replaced in their glass cases, will henceforth be exhibited with their faces uncovered, like the mummies of King Pinotem and the priest Nebsouni.

Given at Boulak, June 3, 1886.

G. MASPERO.

NOTE.—Rameses II. was the third Pharaoh of Dynasty XIX., and began to reign presumably about the year 1430 B. C. He was the greatest builder among the Pharaohs. The two magnificent subterranean temples at Ipsambul in Nubia, the Ramesseum of Thebes, a large portion of the famous temples of Karnak and Luxor, and the small temple at Abydos, are ascribed to him.

Rameses III. was the second Pharaoh of Dynasty XX. His reign probably began about the year 1280 B. C., and was noted for its long series of defensive wars. He is regarded as one of the most eminent of the Pharaohs, and as an admittedly great soldier, in spite of the fact that circumstances prevented him from becoming a conqueror.

THE SPARROWS.

DR. WM. HORNE, an old correspondent to the *Country Gentleman*, was formerly a strong advocate for the English sparrow, but he says he must now give them up: "I am satisfied that the quickly multiplying numbers of this thieving, quarrelsome, murdering foreigner are going to rob us of all our small birds about towns and cities. They do not eat or steal one or two cherries at a time, as the robin, but they puncture some half a dozen at once before being suited. They whip all our small birds, and drive them completely away. My martin and swallow boxes are empty now for three years; my fifteen year visiting bluebirds are also gone for three years; they just showed themselves twice, and were whipped out." "If we wish to preserve our dear little bird friends," says Dr. Horne, "let us rise in our might, and somehow, by poisoned grain or some other way, get rid of the little pugnacious buccaneers."

And this from away off Wisconsin, where we did not suppose the sparrow had yet multiplied to any extent. We have not as yet seen the sparrows taking cherries, but they make such havoc in grain fields as to render grain raising about out of the question wherever they inhabit. They are also very destructive on seed farms, eating and spoiling the seed before it is ripe. We have little doubt that unless there is some general effort made to exterminate them, they will eventually become nearly as destructive in the country as near towns and cities. They have made themselves as much at home in our poultry yards as the fowls themselves, and the amount of the wheat and dough laid out for the hens and chickens that a hundred or more consume in a season is not inconsiderable. Then we have yet to learn that they are beneficial to any degree in destroying injurious insects. The elms on Boston common have been eaten the present summer by caterpillars till their leaves are but skeletons, and the trunks are now covered with the pupa cases, yet we have not seen or heard of a sparrow making a single meal on these leaf-destroyers. We need some St. Patrick to send the sparrows to keep company with the toads and snakes that were made to leave Ireland.—*N. E. Farmer.*

A NEW EDIBLE FRUIT.

THE exotic plants that we meet with in public establishments, or that we find in the collections of amateurs, are usually cultivated for their ornamental qualities, unless, as in the case of most of the specimens reared in greenhouses of botanic gardens, their interest is purely scientific. We ought scarcely to expect to find in these latter anything else than objects for study or plants that yield useful products. It is exceptional to find trees or shrubs with esculent fruit thereon. Moreover, our hemisphere is so well provided with hardy fruit trees of all kinds that we take no trouble to find substitutes for them, which, upon the whole, might require special and burdensome care.

With the exception of the pineapple and banana, hardly any tropical fruits are consumed in France, their culture being capricious, and their flavor never being comparable to what it is in their native country.

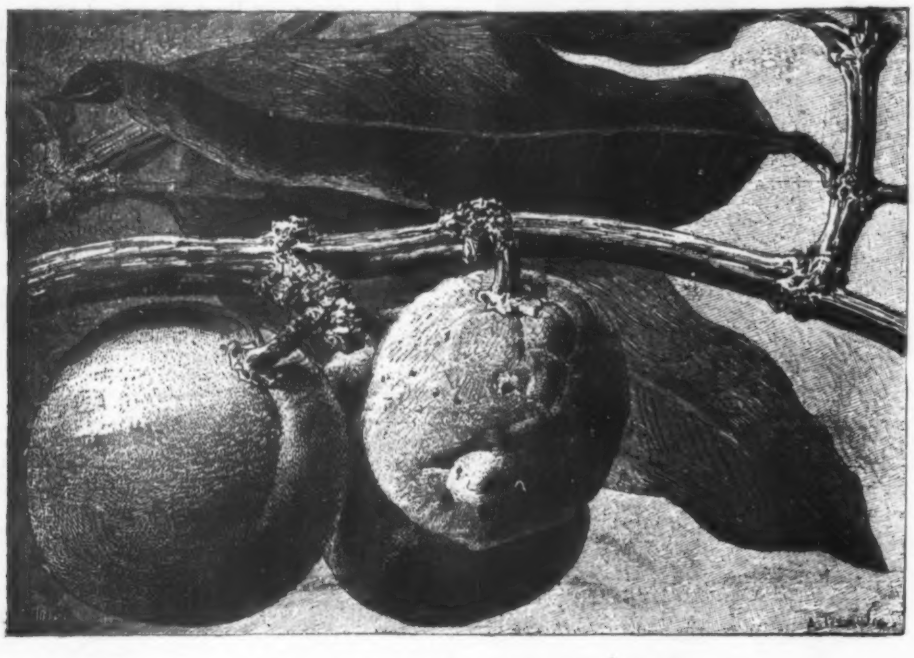
The fruit figured herewith merits a description, and is certainly unknown to most of the readers of this journal. A few words in regard to the family to which it belongs may not seem superfluous.

The order Clusiaceæ, or Guttiferæ, is but sparingly represented in botanic gardens. The species that it embraces belong, almost wholly, to Asia or America, with a few indigenous to other warm regions of the globe. Some of these are celebrated for the products which they yield. The mangosteen (*Garcinia mangostana*) is regarded as one of the most delicious fruits of tropical Asia, and, owing to this fact, has been dis-

THE MUMMY OF THE GREAT EGYPTIAN PHARAOH, RAMESES II.—3,200 YEARS OLD.

tributed throughout the colonies of all hot countries. The mammur, called also the American apricot (*Mammea americana*), is likewise a fragrant and choice fruit, although not so fine a one as the mangosteen. It is a rare thing in France to get a chance to taste these exotic fruits.

Even the orange, which is frequently eaten in Europe, has none of that flavor and sweetness that it acquires in a sunny and torrid clime.



FRUIT OF XANTHOCHYMUS PICTORIUS.

We remember that a friend, a distinguished naturalist of Brazil, threw away as detestable an orange which some one gave him in France, and which, nevertheless, seemed to us exceptionable.

We can judge more easily of the value of gamboge, a juice that exudes from a Clusiaciad (*Garcinia morella*), and probably from a few other species of the same genus. There are few products whose botanical origin has been so difficult to establish as that of gamboge, and yet the latter was known as far back as the beginning of the 17th century, as an active purgative and hydragogue in use in the East. Proscribed, or nearly so, from present European therapeutics, on account of its drastic action, this product has always remained in honor as a yellow coloring matter among water-color painters. Yellow lake gives an incomparable tint, formed by an emulsion of gamboge with water.

All the Clusiaceæ, when their branches are punctured, allow more or less of a gum-resin to escape; hence the name Guttiferæ, proposed by Jussieu, but not generally adopted.

Notwithstanding its specific name, the *Xanthochymus pictorius* does not produce the best gamboge for artists, but it is of interest to us, because it is the one of the Clusiaceæ that best holds its own in hothouse cultivation, and is, perhaps, the only one that chooses to set fruit under favorable circumstances.

The Museum has, for several years past, had a few specimens of this plant, with long leaves of a beautiful green, standing opposite on the branches. Although these are cultivated in pots, they regularly flower and fruit nearly every year. In 1883 we counted forty-five berries upon a single plant. These are first green, and finally of the color and size of a large ripe apricot.

Moreover, we know of another species of the same genus, *X. dulcis*, which derives its specific name from the use made of its fruit in the Moluccas.

Ours, then, is not the only one whose fruit is eaten. The taste of the pulp is saccharine and slightly acid. Spoiled, as we are, by the incomparable fruits of our gardens and orchards, we cannot judge of the value of such a one as we are now considering; it is necessary to have lived in far-distant countries, in order to appreciate the services that certain fruits are capable of rendering.

Acid fruits are rare in hot countries; sugar prevails in most, and Europeans as a general thing do not take to them at once. However this may be, the *Xanthochymus pictorius* is curious in several respects, since it allows us to have in a greenhouse of moderate temperature a shrub of an essentially exotic order, of peculiar aspect, and capable of annually yielding numerous fruits that are in nowise to be disdained.—*La Nature.*

WILLOW GENTIAN OR SWALLOW-WORT.

(GENTIANA ASCLEPIADEA.)

The species represented in the annexed illustration is, as far as we are aware, the only one in this large genus that can be naturalized in woods and similar places with any degree of success. It is not uncommon to see in gardens nowadays large patches of this beautiful plant both in beds and flower borders, but it may not be generally known that it also flourishes equally well in uncultivated places, apparently unmindful of the rank grasses and other weeds with which it may be associated. It is truly herbaceous, dying down out of harm's way in winter and reappearing late in spring, when all chance of injury from frost is past, and flowering at a time when bold masses in such situations are most desirable. It is not difficult to raise from seed even in the open; space cleared round the parent plants at seeding time will produce thousands of young plants the following spring, and these will be ready to flower the second year.

FLOWER-SPRAY OF GENTIANA ASCLEPIADEA.

There is a white-flowered variety of this gentian, also a very desirable plant, either for growing separately or in company with the blue one. When well intermixed, the effect of the two together is most charming, both being about equal in size and habit. Choice of situation is not, however, the least important item as regards its cultivation. It loves shade, in which, if not so dense as to draw and weaken it, it does much better than in places exposed to full sunshine. Attention to watering in dry weather is also essential; it is apparently very susceptible of drought, losing all its lower leaves and becoming unsightly. With us it grows generally from two feet to three feet in height, but it not unfrequently reaches four feet under favorable conditions. It is a useful plant for cutting purposes, its flower-sprays lasting a considerable time in water. It is a native of Southern Europe, and flowers in July and August.—*K., The Garden.*

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